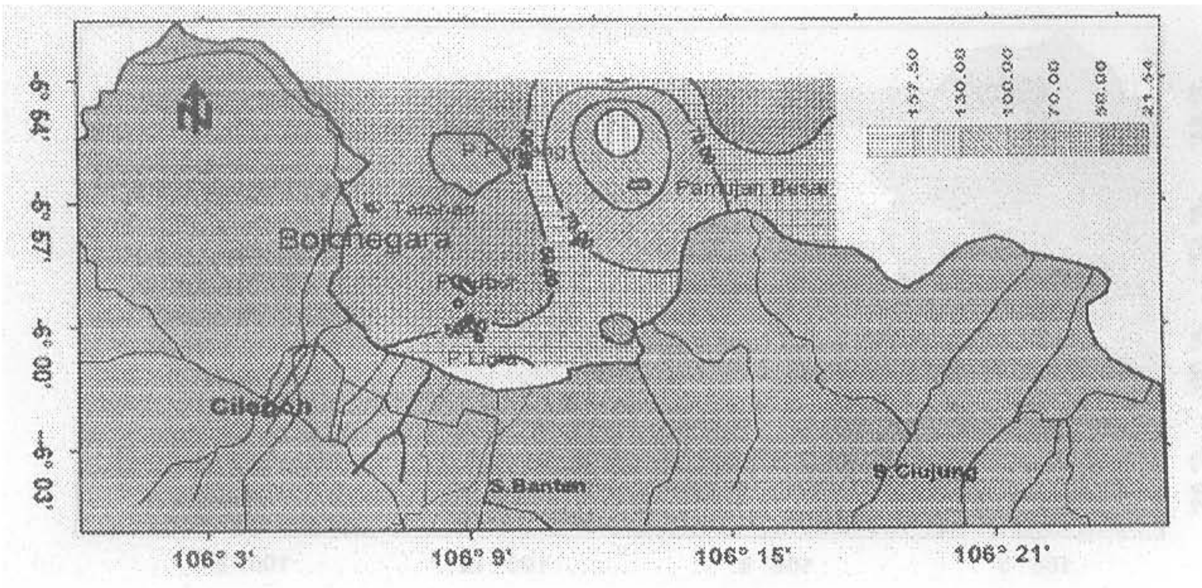


Figure 2.1.2-15   Bottom Depth Suspension Distribution (mgr/l) On April 2001

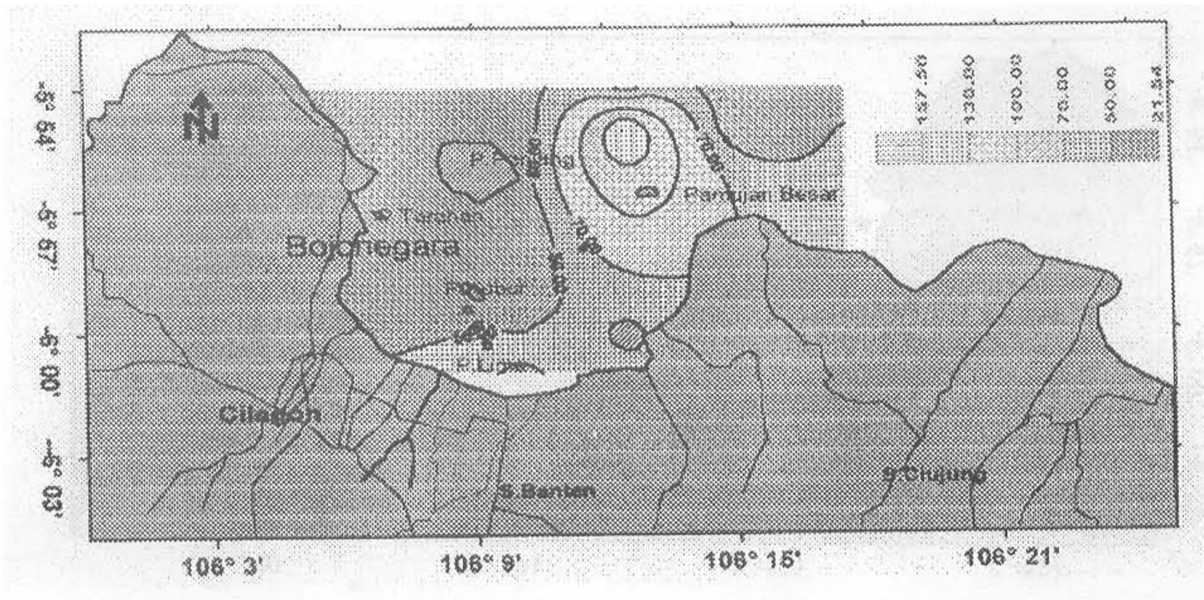


Figure 2.1.2-16   Bottom Depth Suspension Distribution (mgr/l) On June 2001

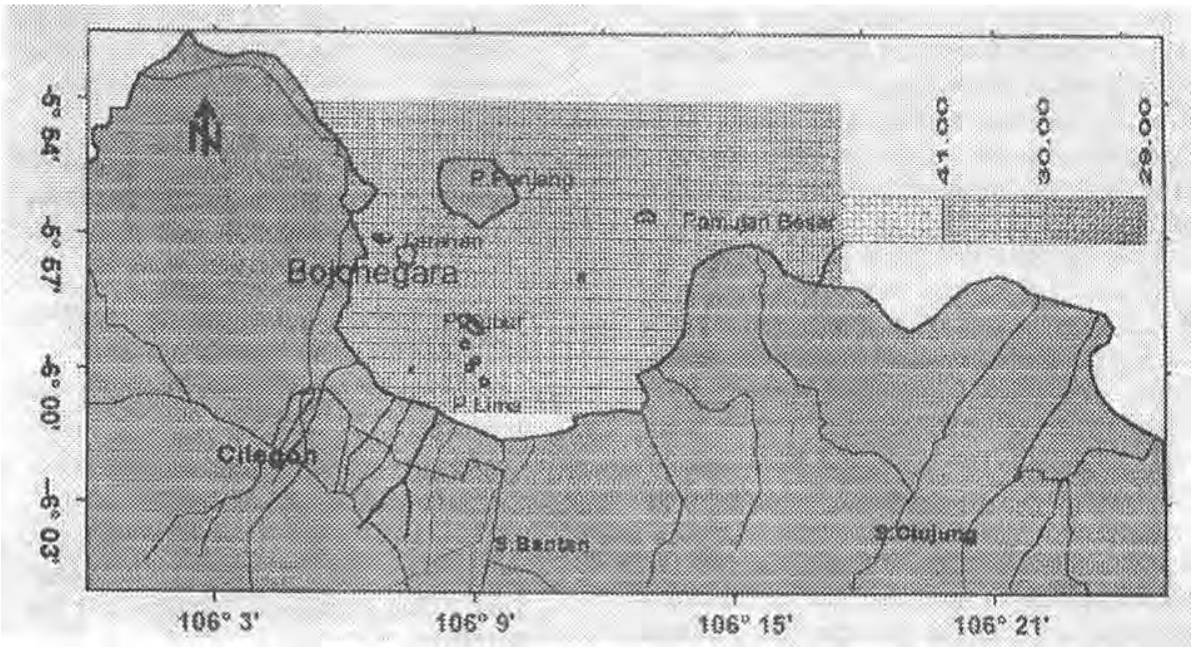


Figure 2.1.2-17   Bottom Depth Suspension Distribution (mgr/l) On August 2001

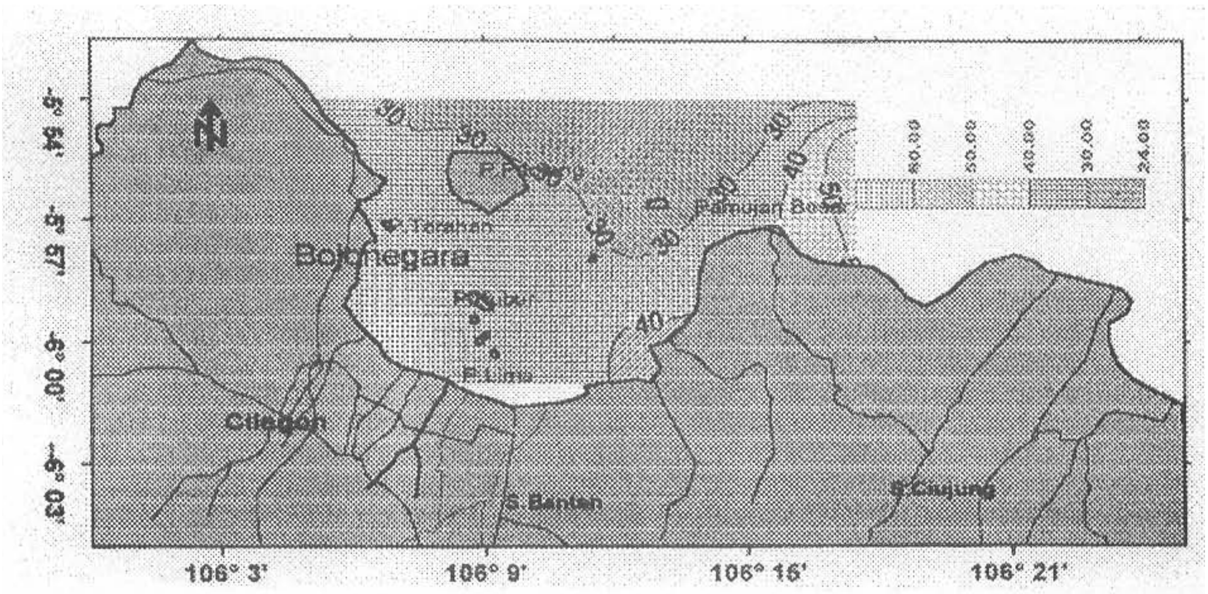


Figure 2.1.2-18   Bottom Depth Suspension Distribution (mgr/l) On October 2001

Figure 2.1.2-3 — Figure 2.1.2-18

Source: Study for Sediment and Suspension Distribution in *Banten Bay*, Central of Oceanographic, *Pusat Penelitian Oseanografi, Lembaga Ilmu Pengetahuan Indonesia*, 2001

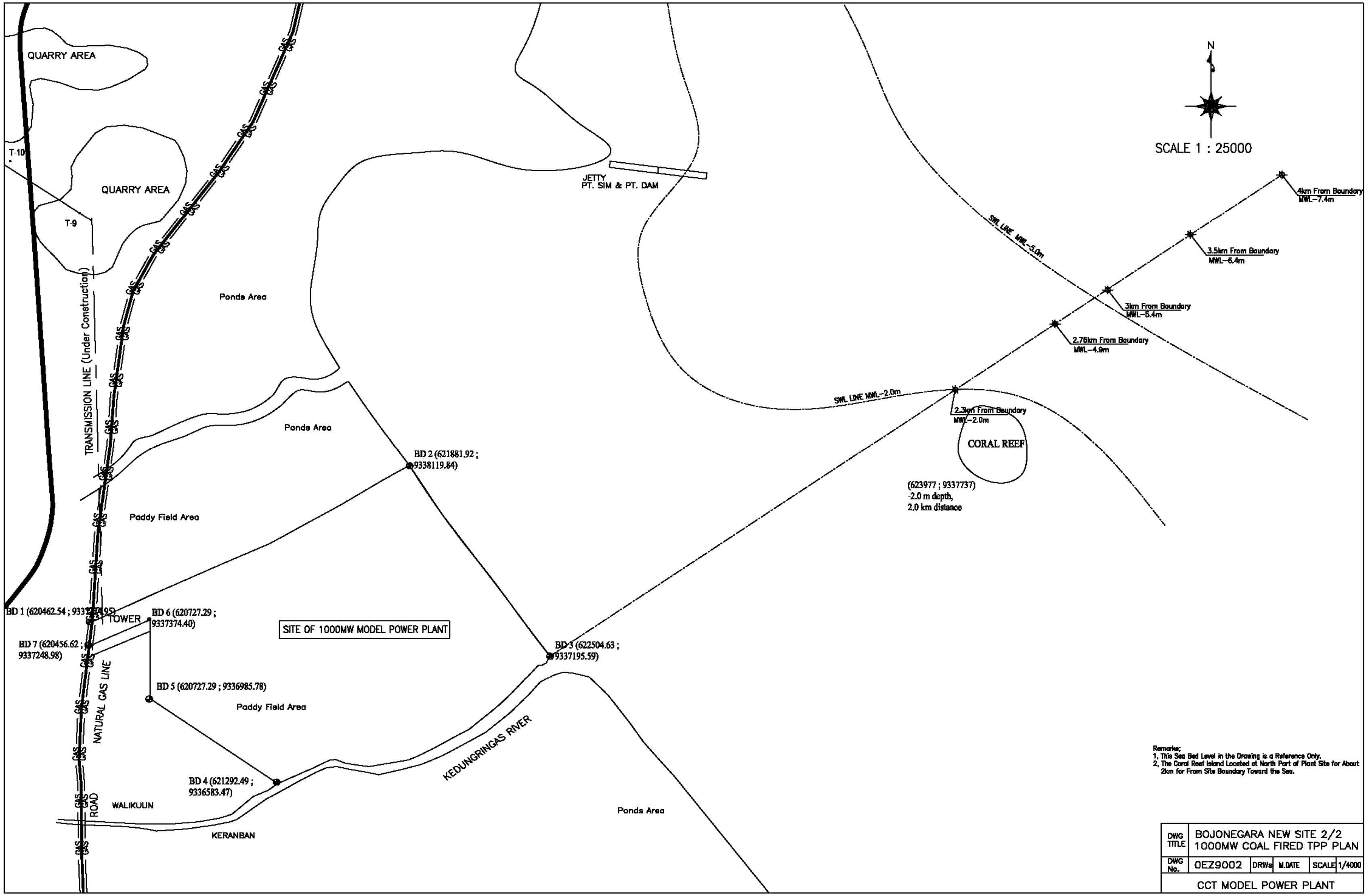


Figure 2.1.2-19 Location Map of Study Site (Off Shore)

Source: JICA Study Team

B Coral Reef Condition

Coral reef survey was carried out by using boat. The survey was conducted by GPS tracking to confirm the coral reef island location, wide and the distance of coral reef island from the study site. On this survey, the observation of the sea bed depth was also conducted. The data of sea bed depth, location and distance from study site was taken at several locations.

The coral reef island located at north part of study site for about 2km far from coastline toward the sea. The coordinate is (624086.72, 9337864.85). Based on GPS tracking by circling the coral reef island, the island has an area of 9.0 959 ha. The depth of coral reef island when high tide is about 2.0 m and low tide the island appears on the surface.

The observations of sea bed depth were carried out at several locations. The survey is aimed to know the depth of sea bed for unloading jetty design. The minimum draft (depth) is necessary 7.5 m for unloading jetty construction. There are 5 observation points around the site for sea bed depth survey, are as follows:

Table 2.1.2-3 Coordinate position of Site Boundaries

No	Coordinate		Sea Bed Depth (m)	Distance from site (km)
	X	Y		
1.	623977	9337737	2.0	2.0 (at coral island)
2.	624562	9337639	5.5	2.76
3.	624863	9337846	6.0	3.0
4.	625372	9338068	7.0	3.5
5.	6255830	9338517	8.0	4.0

Note: The survey was conducted during high tide

Source: JICA Study Team

2.1.3 Natural Condition of Preset Site Area

2.1.3.1 Air Temperature

As for relative humidity data, air temperature data were referenced from *PT. PLN* Feasibility Study Report for LNG power plant 2006.

Daily variation of air temperature varies from 19°C to 39.5°C; with the average is 27.56° C. During 16 years of observation done by BMG, the maximum air temperature (39.5°C) was occurred on November 1976, while the minimum (19.0°C) was occurred on April 1976.

It needs to be noted that such data is a long range record from 1976 up to 1992. For the purpose of design basis of the Project, it is recommended that a conservative and more realistic value is applied, that is 30.0°C. This value is applied similarly for another current project in Indonesia.

2.1.3.2 Atmospheric Air Pressure

Atmospheric air pressure data was also referenced from *PT. PLN* Feasibility Study Report for LNG power plant 2006.

Daily variation of atmospheric air pressure varies from 1,000 mbar to 1,022 mbar; with the average is 1,011.3 mbar.

During 16 years of observation done by BMG, the highest monthly average air pressure (which was happened on April 1991) is 1,020 mbar and the lowest monthly average air pressure (which was happened on March 1975) is 1,008.2 mbar.

2.1.3.3 Humidity

Data of air relative humidity for the Project Site is collected from meteorological station in *Serang*. The data available are the daily of air relative humidity from 1975 to 1992, with three times observation per day. Based on the collection, some conclusion can be drawn as follows:

Generally, the humidity in *Serang* is high; it may be due to the high water vapor concentration of the sea breeze that blows strongly almost everyday. Usually the air relative humidity will be higher during the wet months compared to dry months. However, data of air relative humidity in *Serang* show that air relative humidity is constant during the wet months and the dry months.

The maximum humidity during 1975 to 1992 is 99% (in the morning) and the minimum humidity is 27% (at noon) and the average is 76.29% from all data.

The mean of monthly average of air relative humidity during 1975 to 1992 is 83.20%. The mean of monthly average maximum of air relative humidity reach 86.90% on February 1989. The mean of monthly average minimum of air relative humidity is 64% on July 1975.

The large difference between the maximum average and the minimum average of relative humidity was occurred during the month of July until September, when the rainfall is low. The low of difference between the maximum and the minimum average of relative humidity occur during the months of December until March, when the area experience a high rainfall level.

It needs to be noted that for the purpose of design basis, relative humidity of 83% is recommended. This value is applied similarly for previous project in Indonesia.

2.1.3.4 Rain Condition

The annually rain condition of plant site area is shown below:

THE PRECIPITATION (RAIN) MONTH FOR 30 YEARS (1982 UNTIL 2011)
SERANG SURROUNDING AREA

Unit: mm

YEAR	JAN	FEB	MAR	APR	MEI	JUN	JUL	AUG	SEP	OCT	NOP	DEC
1982	443	136		135	89	24	41	7	-	4	92	112
1983	224	171	135	276	53	44	101	15	3	139	243	120
1984	284	229	302	80	86	84	51	166	103	197	78	180
1985	155	124	134	190	56	196	161	12	182	57	58	114
1986	451	260	96	95	69	75	186	87	154	79	304	211
1987	389	237	132	108	248	22	19	18	3	4	50	254
1988	206	343	163	197	242	88	18	68	25	112	182	254
1989	198	582	62	157	122	50	61	154	61	25	93	259
1990	488	151	213	140	82	136	79	111	8	74	79	304
1991	311	311	181	237	50	13	0.1	-	-	78	133	141
1992	348	344	189	170	35	86	31	88	159	148	261	184
1993	354	231	52	246	173	103	33	150	71	44	224	87
1994	214	315	266	125	35	36	-	-	11	39	126	85
1995	393	266	262	221	102	92	166	22	59	90	248	205
1996	292	341	193	261	212	93	9	133	78	233	230	285
1997	295	171	147	199	143	33	2	-	-	-	39	89
1998	170	209	243	114	222	113	60	94	43	231	133	166
1999	329	238	96	100	40	53	55	15	20	151	76	248
2000	383	336	95	127	132	29	101	22	24	117	134	72
2001	222	330	143	85	62	164	64	49	96	136	190	74
2002	292	348	118	260	88	86	125	3	5	8	97	176
2003	83	253	128	47	78	11	50	5	41	44	117	320
2004	221	348	176	86	174	4	51	0	58	33	81	235
2005	305	287	192	87	41	163	185	44	66	147	70	182
2006	224	234	345	85	152	31	10	8	0	6	11	150
2007	207	301	250	92	152	68	48	2	8	118	73	204
2008	209	349	133	89	95	54	0.2	73	33	71	245	125
2009	339	306	131	113	102	29	3	2	17	20	279	45
2010	322	195	166	72	113	167	208	123	328	186	148	109
2011	242	91	204	107	85	38	79	0	32	71	79	112

2.1.3.5 Wind Condition

Assets by the overall wind data show the dom inant winds blow from the north with an average speed of 1.5 to 4.0 m/s. Table2.1.3-1 shows the distribution of wind speed and direction at the station Attack and Figure2.1.3-1 station area shows wind rose Attack

Wind data was obtained from Meteoro logy and Geophysics Agency (BMG), y ear 2000 – 2010. Recapitulation of overall wind data show the dom inant winds blow from the north with a n average speed of 1.5 to 4.0 m/s. Table 2.1.3-1 shows the distributio n of wind sp eed and direction and Figure2.1.3-1 shows wind rose at the *Serang* station.

An overall Wind rose in the above-mentioned region is represented the following Figure2.1.3-1.

Table 2.1.3-1 Wind Data (Distribution of wind Direction & Speed Year 2000-2010

Location : Bojonegara Bay										
Wind Direction	**<0.5 m/s**	**0.5-1.5 m/s**	**1.5-4 m/s**	**4-6 m/s**	**6-9 m/s**	**9-12 m/s**	**12-17 m/s**	**>17 m/s**	**Total**	**%**
N	0	1	876	529	58	1	3	13	1481	36.86
NE	0	0	190	118	18	3	0	1	330	8.21
E	0	2	180	113	20	5	0	0	320	7.96
SE	0	0	47	8	0	0	0	2	57	1.42
S	0	1	127	61	10	4	0	2	205	5.10
SW	0	0	59	49	22	3	0	1	134	3.33
W	0	0	296	438	227	56	6	1	1,024	25.49
NW	0	0	108	83	6	0	0	3	200	4.98
X*	* not recorded								267	6.65
									4,018	100.00

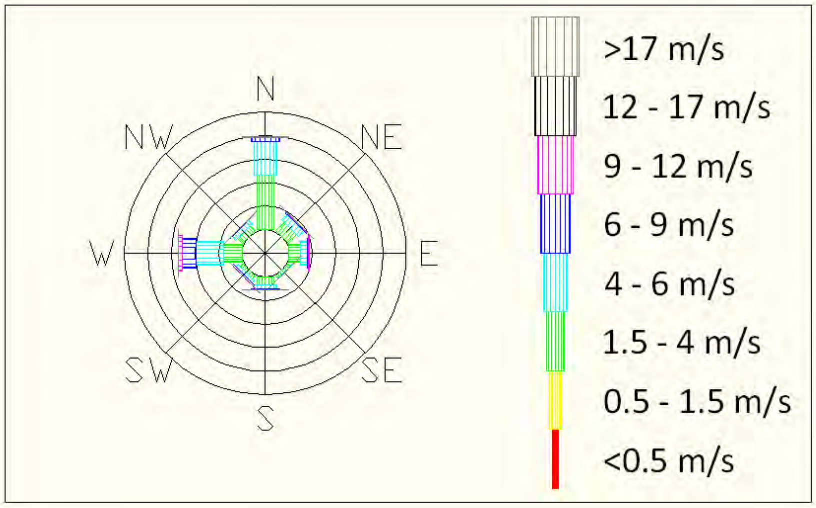


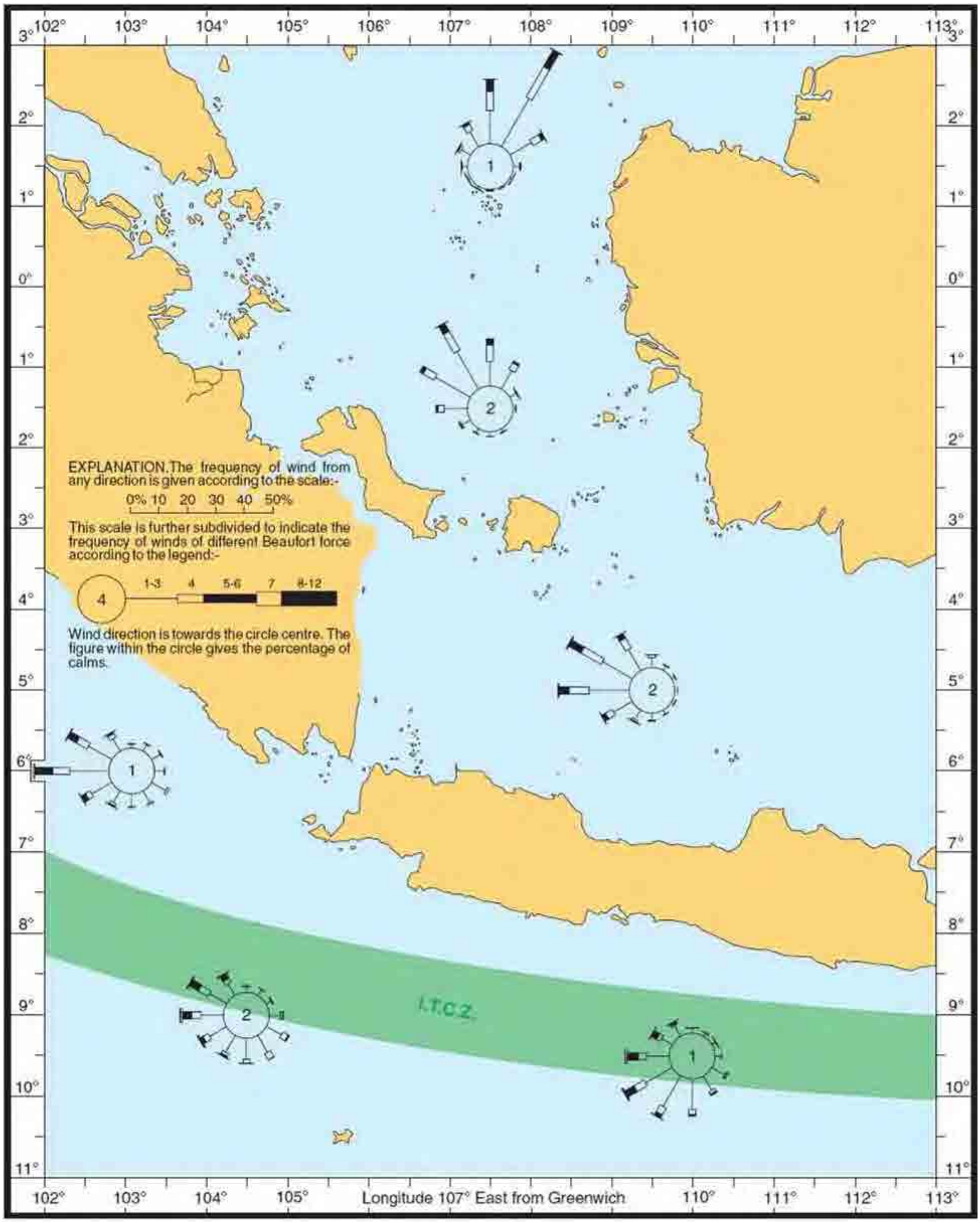
Figure 2.1.3-1 Windrose (*Serang* Station) Year 1998-2008

Based on the Indonesia Pilot Volume I, the wind roses showing the frequency of winds of various directions and speeds in January, April, July and October are given in Figures 2.1.3-2 to 11.

Winds over the open sea are governed by the seasonal pressure change and the position of the ITCZ (Intertropical Convergence Zone). Between November and March the ITZC lies to the south of Java with the northwest monsoon affecting areas to the north. Winds in the north of area, to the north of equator, are mainly north-northeast but slowly back northwest in central areas and then to the west-northwest in the south. Between June and September the ITZC lies well to the north of the area, and mainly south-southeast winds in the south that slowly veer to the south-southeast in the north.

Average winds strength ranges from around force 2 to 4 during the northwest monsoon and slightly less with the southeast monsoon. Between November and March the frequency of winds of force 5 and above is about 10 – 14% in the north and south of the area, and 5 – 8% in central areas. Between June and September the frequency of winds of force 5 and above are about 3 – 5% in the north and 5

– 7 % in central and south areas.



Source: Indonesia Pilot Volume I

Figure 2.1.3-2 Wind distribution in January and mean Position of ITCZ;

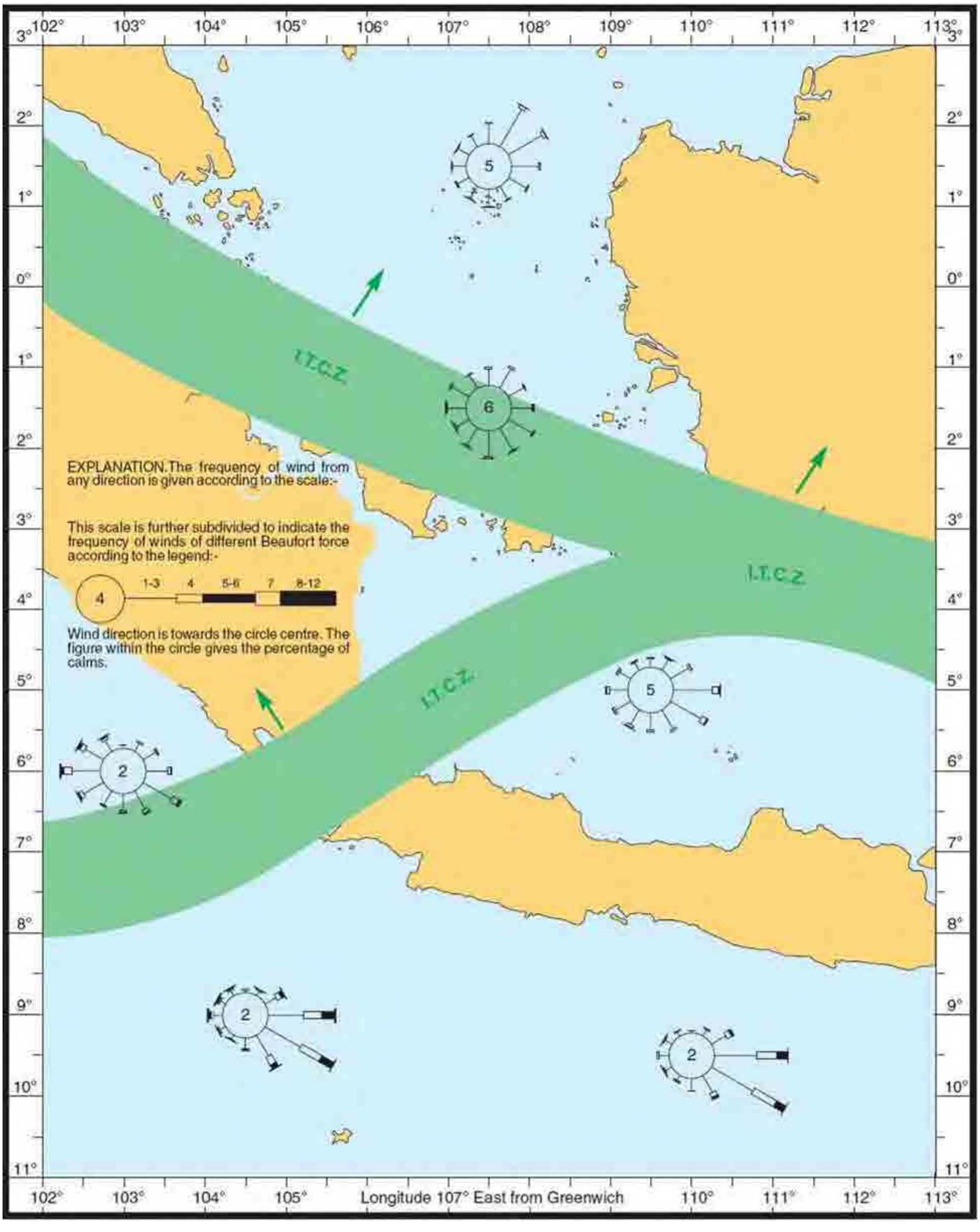


Figure 2.1.3-3 Wind Distribution in April and mean Position of ITCZ;

Source: Indonesia Pilot Volume I

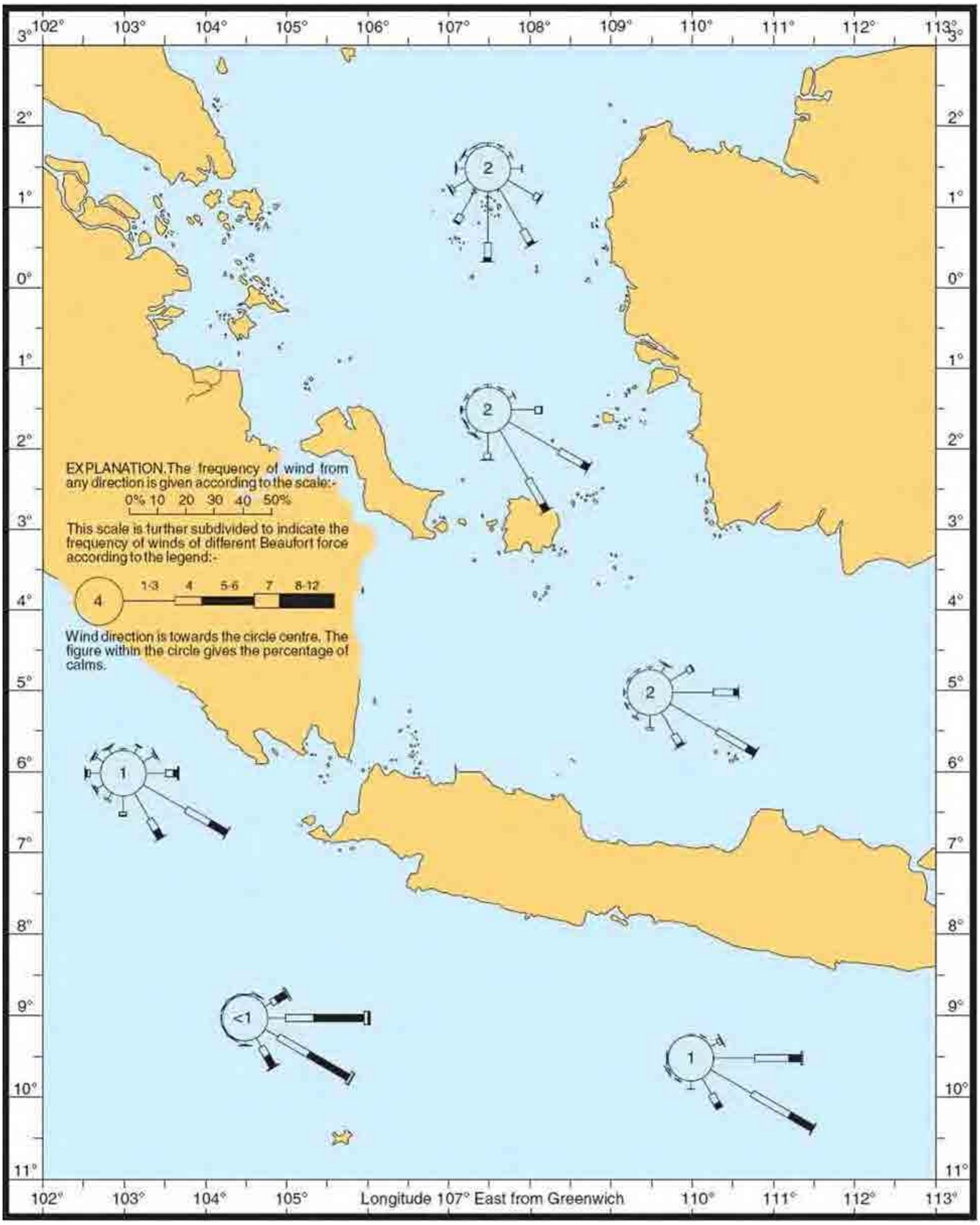


Figure 2.1.3-4 Wind Distribution in July;

Source: Indonesia Pilot Volume I

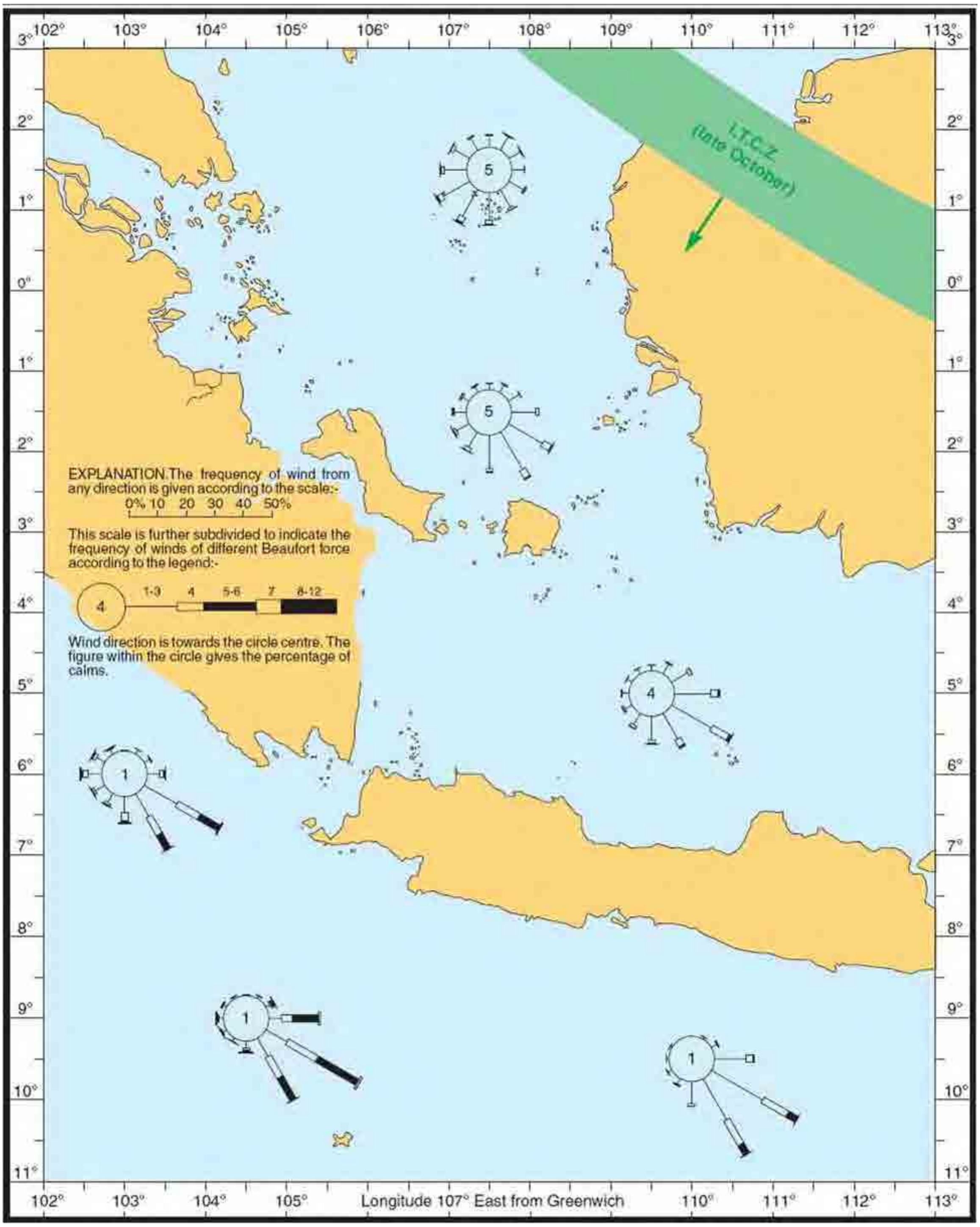


Figure 2.1.3-5 Wind Distribution in October and mean Position of ITCZ;

Source: Indonesia Pilot Volume I

2.1.3-6 Seismic Condition

Considering the seismic coefficient zone Map (*T. Nayoan* DPMA 2002) on Figure 2.1.3-6 the seismic zone coefficient (Z) of study site is within zone E with (Z) = 1.2 – 1.4 (average 1.3).

In order to define the peak ground acceleration of the site survey area, the following formula is to be used:

$$ad = Z \times ac \times v$$

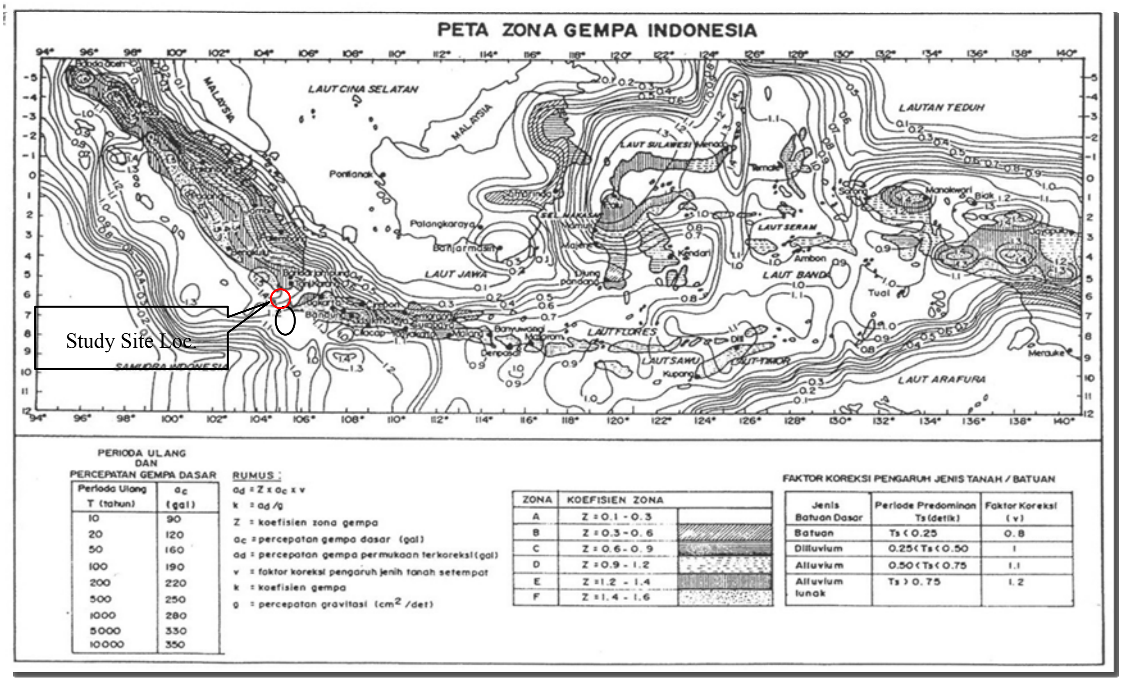
$$k = \frac{ad}{g}$$

Where:

Z	= seismic zone coefficient
ac	= ground seismic acceleration (gal)
v	= correction factor, depend of ground type
ad	= design peak ground acceleration (gal)
g	= gravity acceleration (cm^2/sec.)
k	= seismic coefficient

According to formula above and Figure 2.1.3-7, the ground seismic acceleration ac = 190 for 100 years return periods. The ground type at study site is dense sand, hence the correction factor v = 1.1.

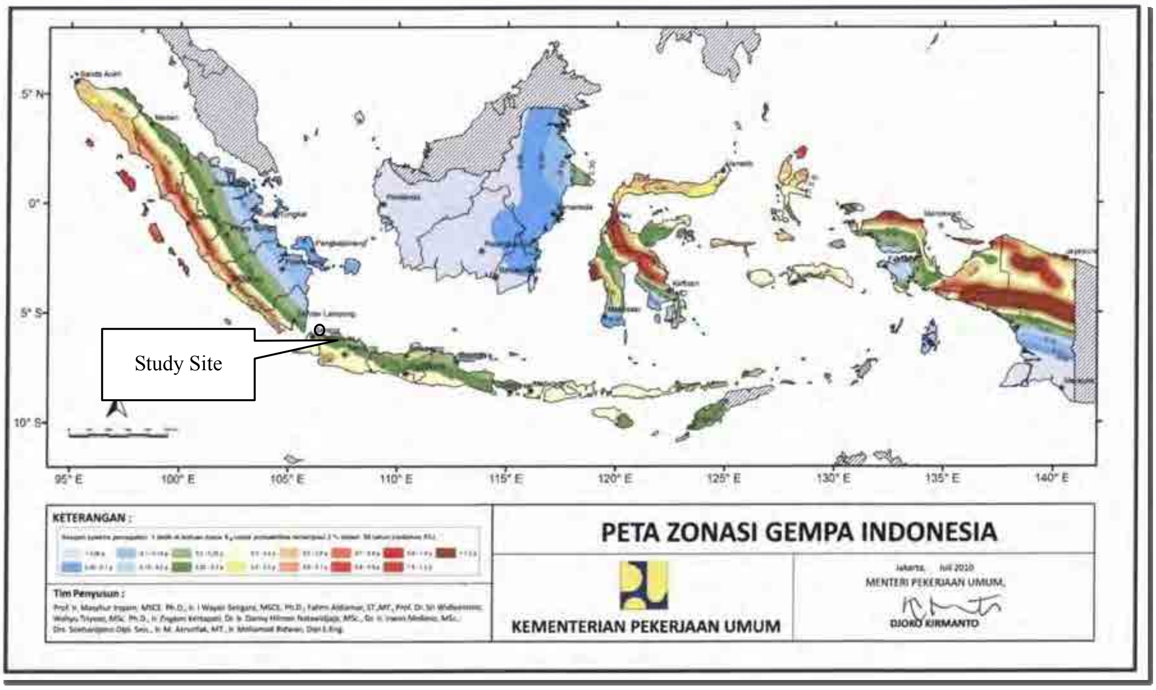
Based on parameter and by using the formula above, the design peak ground acceleration of site survey area is ad = 271.7 gal and seismic coefficient k = 0.28 g.



Source: T. Nayoan DPMA 2002

Figure 2.1.3-6 Indonesia Seismic Coefficient Zone Map

If referring to the newest Indonesian Earthquake Zone published in 2010 by Public Work Ministry, the site survey lies on “seismic coefficient at bed rock, a = 0.25 – 0.3 g”.



Source: Public Work Ministry, 2010

Figure 2.1.3-7 Indonesia Earthquake Zone 2010

2.2 Condition of Infrastructure for Study Site

The existing infrastructures available surrounding the study site can be described as follows;

2.2.1 Access Road

The access road from the capital city of Jakarta to project site is mostly through *Jakarta – Merak* Toll Road 97 km and from *Cilegon Timur* exit Ramp for approximately 4 km to the project site is concrete rigid pavement road with 10 m wide, Road Class I with road capability to bear single axle load of more than 10 tons.

In general, the concrete pavement of access road is in fair condition with view or spot damage.

Information from the Provincial Regional Planning Board (*Bapedda Banten*), there is a plan to establish toll road between *Cilegon* to *Bojonegara*, close to site area.

2.2.2 Railway

Jakarta - Merak railway passes through approximately 1 to 3 km far from the study site.

2.2.3 The Nearest Loading-Unloading Jetty Facility

The nearest loading-unloading and marine transportation facilities is a private loading jetty facility owned and operated by *PT. SIM & PT. DAM*, which located approximately 2.0 km far from study site.

PT. SIM operates the loading-unloading activity of jetty facilities and *PT. DAM* supplied the stone aggregate. The activity of jetty are loading-unloading of stone aggregate & coal for domestic (*Batam & Kalimantan* barges, capacity 5,000 tons, 10,000 tons) and international destination (Thailand).

(Refer to Figure 2.1.1-1. Location Map of 1,000 MW Coal-Fired Thermal Power Plant)

2.2.4 500 kV Transmission

It is visible from the stud y site, tha t there an e xisting construction of tower for ne w power transmission line from *Suralaya* Power Plant, which is not completed yet for the entire route.

The tower construction was establish in 2010 an d supposed to be continue crossing the study site but actually stopped at the front side of study site. Some infor mation says that *PT. PLN* as the owner refused to have the tower construction crossing their land. Position of existing new tower to be plotted on map

Figure 2.2.4-1 The New Power Transmission Line of 500 kV form *Suralaya* PP

The existing and operated power transmission line form *Suralaya* Power Plant is 500 kV and the new power transmission line is planned for 150 kV.

<u>MV Electrical power connection</u>

For power plant construction the re quired temporary electrical power can be from *PT. PLN* transmission line and owned diesel engine generators. *PT. PLN* 20 kV network witch is available near (approx. 500 m until 600 m) study site; electrical p ower can be tapped from this line to the 20 kV transformer in study site.

2.2.5 Coal Resources

Unloading berth/jetty will be constructed in study site sea on shore for coal unloading and coal i s transported from *Sumatra* or *Kalimantan* by coal vessels/barges, and unloading jetty will be used for the unloading of fuel oil as well.

Possibility coal supply area and data;

Possibility coal suppl y to the Model Power Plan t in Indonesia is expected coal mine that is

Kalimantan.

Specifications of coal are as follows:

Table 2.2.5-1 West Kalimantan Area

Coal Mine	Water Content	Heat Value	Ash Content	Surfer Content
West Kalimantan	%	kcal/kg (gar)	%	%
Insani Bara Perkasa	25.0%	**3,800**	5.00%	0.70%
Tabang	40.0%	4,000	5.00%	1.00%
Kideco Samarangu	35.0%	4,100	2.50%	0.10%
Pesona Khatulistiwa Nusantara	33.1%	4,470	1.10%	0.50%
Pesona Khatulistiwa Nusantara Kelubir	42.8%	4,470(adb)	3.58%	0.10%
Pesona Khatulistiwa Nusantara Wonomulyo	39.1%	4,470(adb)	2.55%	1.17%
Pesona Khatulistiwa Nusantara Mangkupadi	64.1%	4,045(adb)	3.00%	0.09%
East Kutai Coal Project		4,000		
Karya Bumi Baratama		**3,200**		
Tekno Orbit Persada	30.0%	4,400	3.50%	0.10%
Tekno Orbit Persada (Middle Eaat coal)	40.0%	3,800		
Ilthabi Baru Utama		4600-5400		
Delma Mining	51-62%	4655-5277		
Bhakti Energy Persada	47.0%	3,343		
Amugerah Bara Kalim	30.6%	4,520		
Batua Energi Prima	40.0%	3,300		

Source: PT. PLN

Table 2.2.5-2 South Kalimantan Area

Coal Mine	Water Content	Heat Value	Ash Content	Surfer Content
South Kalimantan	%	kcal/kg (gar)	%	%
Arutmin Mulia	35.0%	4,221	3.90%	0.20%
Borneo Indobara	36.0%	4,200	8.00%	1.00%
Jorong Barutama Greston	30.0%	4,470	4.00%	0.30%
Adaro Wara	38.0%	4,100	2.00%	0.15%
	40.0%	4,715	2.50%	0.16%
	45.0%	4,555	3.30%	0.23%
Energi Batubara Lestari	37.0%	**3,980**	4.00%	0.20%
Bhumi Rantau Energy	37.0%	**3,980**	4.00%	0.20%
Antang Gunung Meratus Warukin	25-45%	5,200-5,500	2-5%	0.1-0.5%
Bara Pramulya Abadi	35.9-54.9%	4,239-4,961	1.2-4.4%	0.19-1.58%

Source: PT. PLN

Table 2.2.5-3 South Kalimantan Area

Coal Mine	Water Content	Heat Value	Ash Content	Surfer Content
South Sumatra	%	kcal/kg (gar)	%	%
Nusantara Thermal Coal		4,200		
Abadi Batubara Cemerlang		4,200		
Adimas Baturaja Cemerlang		**3,500**		
Astaka Dodol A	21-46.7%	5,035-6,290(adb)	0.9-11.4%	0.1-0.9%
Astaka Dodol B	46-63.2%	3,915-5,865(adb)	2.1-9.4%	0.1-0.4%
Astaka Dodol C	34.1-57.4%	4,426-5,765(adb)	3-12.5%	0.1-0.6%
Astaka Dodol D	36.5-40%	5,470-5,650(adb)	2.5-7.2%	0.2-0.7%
Bara Sentosa Lestari		4,200		
Batualam Selaras Kikim	20.9-34.5%	4,782-6,626(adb)	0.8-8.8%	0.19-0.67%
Batualam Selaras SP-6	19.2-39.7%	5,385-5,820(adb)	1.2-4.5%	0.19-0.74%
Baturona Adimulya Muara Teladan	50-61.5%	4,999-5,360(adb)	3.3-6.8%	0.2-0.5%
Baturona Adimulya Keluang	37.6-51.8%	4,880-5,730(adb)	2.5-12.3%	0.3-2.6%
Baturona Adimulya Lais	52.3-54.3%	5,095-5,600(adb)	3.5-10.2%	2.10%
Pendopo Energi Batubara Benuang	47.8-58.9%	4.620-5.282(adb)	6.2-15.3%	0.1-1.7%
Pendopo Energi Batubara Sigoyang	50.9-59.2%	4,820-5,200(adb)	4.2-8.3%	0.2-0.4%
Sriwijaya Bintangtiga Energy		4,400		
Sugico Pendragon Energy		4,400		
Titan Mining Energy		4,200		
Baramutiara Prima	30.0%	4,400	5.00%	0.35%
Baramutiara Prima(Berlian)	40-48%	3245-4014		
Selo Argokencono Sakti	32.8-52.1%	4,425-5,725(adb)	2.3-11.1%	0.1-0.26%

Source: PT. PLN

2.2.6 Industrial Water Supply

The actual existence of water supply pipe distribution around site location was not visible e specially of those belong to local water supply company (*PDAM*).

The supply for water for most of the industrial purposes around study site is taken from the pipe distribution line of *PT. Sauhbahtera Samudera*, a private raw wat er supply agency based at *Serang* District, *Banten* Province.

Information given from local consumer that wa ter price from the private water supply is Rp. 7,870 /m^3 with minimum 96 m^3 per month, which is much higher compare to water fro m *PDAM* for Rp. 1,500/m^3. The price of water fro m *PDAM* is much less then it is from private water supply only that the water supply from *PDAM* is not reliable as its not always available when needed.

The supply for household consumer around the site is supplied from local government water supply agency (*PDAM*) although refer to the collected infor mation from local resident that the water fro m *PDAM* is rarely available.

It was found during the visit, the existence of Water Treatment facility of *PDAM* which located just near the site only that this facility was abandon and no longer in operation due to lack of raw water source from adjacent rubber dam/river especially during this long dry season.

Figure 2.2.6-1 Water Treatment Facility of *PDAM*

The rubber dam received water from 2 rivers which flows from *Rawa Danau*, *Serang* District and the other from water reservoir for Water Treatment Plant of *PT. Krakatau Tirta Industri/KTI* (*Krakatau* Water Industry Company) located at *Krenceng* Sub-District of *Cilegon* City District.

<u>Scheme of Industrial Water Supply</u>
Herewith is the brief explanation on scheme of industrial water supply for *Cilegon*, *Serang*, *Merak* and surrounding area. Although it is not directly affecting to *Bojonegara* area but it will provides information on water providence for industrial requirements.

The water supply for industrial requirements at the area mentioned as above is mostly provides by *Krakatau* Water Industry Corporation (*PT. Krakatau Tirta Industri*).

PT. Krakatau Tirta Industri is state owned company with main purpose to supply the requirement of water for their own industrial activities covering steel manufacturing, industrial estate, and *Krakatau* staff housing. But due to large capacity of their water treatment facility, *PT. KTI* also able to supplies several industrial zone and ports around *Cilegon* and *Merak* area such as *Gunung Sugih* Industrial zone, Port of *Ciwandan*, *Ciwandan* Industrial zone, Port of *Cigading*, *Krakatau* Industrial Estate *Cilegon*, *Gerem* Industrial zone, Ferry Port of *Merak*, Industrial Port of *Merak* and *Suralaya* Power Plant, including supply to Local Government Water Company (*PDAM*) as partners to distribute water requirement for households/residential consumer.

2.2.7 Availability of Local Construction Material

A. Concrete Batching Plant

There are 2 locations of concrete batching plant company around the study site. The first company is *PT. SDB*. The location is on coordinate (620336, 9335326). The company operates 2 silos with capacity 35 m^3/hour approximately.

The second company is *PT. Jayamix*. The location is on coordinate (620314, 933520). The company operates 4 silos with capacity 70 m^3/hour.

The average concrete batching plant capacity is ranging from 60 – 80 m^3/hour. In the special case of construction which requires huge amount of concrete, it is common to make special contract with chosen concrete supplier to establish exclusive concrete batching plant within construction compound with specific capacity as required.

B. Others

Generally, various construction materials are available both locally and regionally . These could be domestically available of imported. These are among others;

- Cement factories are available in various plants in *Java*, i.e. *West Java*, *Central Java* and *East Java*. Both type I and II cements are available. (Type V will be necessary for sea berth.)
- Other material such additive, concrete steel, structural steel metal cladding and etc., are available through manufacturer and/or agents /distributors both for local and imported materials.
- Aggregate material is available near the study site location.

CHAPTER 3

BASIC CONCEPT OF THE MODEL POWER PLANT

CHAPTER 3
BASIC CONCEPT OF THE MODEL POWER PLANT

Basically, most of USC power plant system and facilities are of a very similar structure to a super critical power plant. This part will explain of the major system of USC and major important facilities such as the Boiler, Coal Pulverizer, Dust Collector, Coal Handling system, Ash Handling system, Ash Disposal area, DeSOx system, DeNOx system, Steam Turbine and Cooling Water system.

This Model Power Plant should be designed considering the advanced technology of Ultra Super Critical (USC) steam condition as an environmental harmonized type of coal fired power plant.

In this preliminary feasibility study (Pre-FS), JICA study team summarized the result of basic study for Model Power Plant. A more detailed study and design should be carried out in feasibility study (FS) in future.

3.1 Design Requirements of Model Power Plant

(1) Design Requirements

The Model Power Plant should be a single unit 1,000 MW of USC, and the design requirements are as follows.

Table 3.1-1 Design Requirements for Model Power Plant

No.	Name of criteria	Unit	Data
1	Rated Output	MW	1,000
2	Number of Units	Unit	1
3	Plant Efficiency (HHV)	%	40
4	Plant Capacity Factor/Availability Factor	%	80/84
5	Annual Operating hours	h/y	7,358
6	Annual Gross Generation Output	GWh/y	7,008
7	Auxiliary power consumption rate	%	8.0
8	Annual Net Generation Output (@ Main Transformer end)	GWh/y	6,447
9	Boiler Efficiency (HHV)	%	>84
10	Turbine Efficiency	%	>47
11	Fuel Consumption		
a.	Heating Value of coal (Gross as received)	kcal/kg	4,000
b	- Per hour (100% load)	t/h	538
c	- Per day (Averaged, CF = 80%)	t/d	10,400
d	- Per month (Averaged, CF = 80%)	t/Month	314,000
e	- Per year (CF = 80%)	t/y	3,767,000
f	- Coal storage yard capacity	days	36
12	Capacity of Ash disposal area	Years	5

Source: JICA study team

(2) Rated Condition

Rated Condition of Steam/Water Cycle is as follows

Table 3.1-2 Rated Condition of Steam/Water Cycle

No.	Item		Rated Value	Remarks
1	Main Steam (at Boiler outlet)	Pressure	25.4 MPa (g)	
		Temperature	605^{o}C	
2	Reheat Steam (at Boiler outlet)	Pressure	3.83 MPa(g)	
		Temperature	623^{o}C	
3	Main Steam (at HP Turbine inlet)	Pressure	25.0MPa (g)	
		Temperature	600^{o}C	
4	Reheat Steam (at IP Turbine inlet)	Temperature	620^{o}C	
5	Condensate Vacuum & Saturated Temperature		Approx.8.47kPa (a), 42.6^{o}C	Sea Water Temp. 30^{o}C
6	Sea Water Temperature		30^{o}C	At CW intake point

Source: JICA study team

(3) Rated condition of Environmental standard

1) Flue gas emission Environmental Standard.

Model Power Plant should be equipped with CEMS (Continuous Environment Measurement System) at stack. In the case of CEMS applied power plant, environmental standard will be as follow:

Table 3.1-3 Environmental Standard of Coal Fired Power Plant for Flue Gas Discharge (with CEMS)

No.	Parameter	Maximum Limit (mg/Nm^3)
1.	Total Particle	100
2.	Sulfur Dioxide (SO_2)	750
3.	Nitrogen Oxide (NOx)	750
4.	Opacity	20 %

Source: Annex 2 the Decree of Jakarta Governor No. 670 Year 2000 regarding the Emission Gas Standard from Fix Sources

3.1.1 Basic Operating Condition

As an operating condition of this model plant, in order to relieve the electric power shortage of Jakarta, Model Power Plant will be used as base operation plant.

(1) Capacity factor and Availability factor of plant operation

The capacity factor and availability factor in Model Power Plant will be as follows

- Capacity Factor (CF) : 80%
- Availability Factor (AF): 84%

AF (%) = (8,760 (h) – Outage hour) / 8,760 (h)

Where: 8760 (h) = 24 (h/day) × 365 (day/year)

CF: Capacity Factor is the ratio of the annual actual generation output of a power plant divided by annual generation output under the rated capacity.

CF = Annual actual generation output / (8,760 h × 1,000 MW)

AF: Availability Factor is the ratio of the annual actual generating hours divided by yearly hour.
AF=Annual actual generation hours/ 8760h

Outage hour: Outage hour is Annual planed maintenance period and forced outage (trouble period).

Annual gross generation output (GWh)
= Rated Capacity (MW) × 8,760 (h) × Capacity Factor (%) / 1,000 (kWh/MWh)
= (1,000 (MW) × 8,760 (h) × 0.80) / 1,000
= 7,008 (GWh)

Annual net generation output (GWh)
= Annual gross generation output × (100 - Auxiliary power consumption ratio) / 100
= 7,008 (GWh) × (100 - 8) × 100
= 6,447 (GWh)

Annual operation hour (h)
= Yearly hour ×Availability Factor
= 8,760 (h) × 0.84
= 7,358 (h)

3.1.2 Design coal

The Design coal is used to design the equipment for Model Power Plant.

PLN provided specification of Design coal to JICA study team and its specification is as follows:

Table 3.1.2-1 Parameters of Design coal

Description		Range		Typical
		Minimum	Maximum	
Proximate Analysis (% as received)				
	Total Moisture	25	40	35
	Inherent Moisture	13.8	25	18
	Ash	3.3	6	5
	Volatile Matter	27.9	40	35
	Fixed Carbon	23	41	25
Specific Energy (as received)				
	Gross Calorific Value (GCV) = Higher	3,700	4,300	4,000
	Heating Value (HHV) (kCal/kg)			
Ultimate Analysis (% dry ash free)				
	Carbon	65	80	68.2
	Hydrogen	3	2.9	5.7
	Nitrogen	0.54	1.2	1.13
	Oxygen	12	30	23.17
	Sulphur	0.13	2.2	1.8
Description		**Range**		**Typical**
		Minimum	**Maximum**	
Ash Analysis (%)				
	SiO_2	2	60	34
	Al_2O_3	3	52	6
	Fe_2O_3	4.7	52.5	39
	TiO_2	0.02	4.1	0.48
	Mn_3O_4	0.2	8.8	2
	CaO	0.8	27.7	10
	MgO	0.02	32.6	5
	Na_2O	0.05	4.12	0.71
	K_2O	0.1	2.4	1.3
	P_2O_5	0.03	0.8	0.51
	SO_3	0.2	24.6	1
Ash Fusion Temperature (°C)		Reducing	Reducing	Reducing
	I.D.T. (deformation)			1,050
	S.T. (softening)			1,100
	H.T. (hemispherical)			1,150
	F.T. (fluid)			1,200
Ash Fusion Temperature (°C)		Oxidizing	Oxidizing	Oxidizing
	I.D.T. (deformation)			
	S.T. (softening)			
	H.T. (hemispherical)			
	F.T. (fluid)			
Hardgrove Grindability Index (HGI)		40	65	50

Source: PLN

3.1.3 Coal consumption

Calorific value of Design Coal was informed by PLN, and the values are 3,700 to 4,300 kcal/kg. Average Calorific Value in annual uses is 4,000 kcal/kg, this value was also informed by PLN. Coal consumption as shown below;

- Gross Calorific Value (HHV) : Typical 4,000 kcal/kg (GAR)
- Total moisture content : Average 35% (25% to 40%)
- Ash content : Average 5% (3.3% to 6.0%)
- Sulfur content (dry ash free) : Average 1.8% (0.13% to 2.2%)

Calculation of Annual Coal Consumption

$$CC\ (t/y) = MWg \times 8{,}760\ (h) \times CF / 100 \times (860 \times 10^3) / (\eta pg / 100) / (GCV \times 10^3)$$

Where:

CC	: Annual Coal Consumption (t/y)
MWg	: Rated output 1,000 (MW)
860×10^3	: Conversion factor of electric power from [MWh] to [kcal/h] (kcal/MWh)
ηpg	: Power plant gross efficiency 40 (%)
GCV	: Gross Calorific Value of coal 4,000 (kcal/kg)
8760	: Calendar hour of year (h/y)
CF	: Capacity Factor 80 (%)

$$CC\ (t/y) = MWg \times 8{,}760(h) \times CF/100 \times (860 \times 10^3) / (\eta pg /100) / (GCV \times 10^3)$$
$$= (1{,}000 \times 8760) \times (80/100) \times (860 \times 10^3) \times (40 /100) / (4{,}000 \times 10^3)$$
$$\cong 3{,}767{,}000\ (t/y)$$

Therefore:

Annual coal consumption	: ≅ 3,767,000 (t/y)	
Averaged monthly coal consumption	: ≅ 314,000 (t/Month)	(CF=80%)
Averaged daily coal consumption	: ≅ 10,400 (t/day)	(CF=80%)
Averaged hour coal consumption	: ≅ 538(t/h)	(CF= 100%)

3.1.4 Boiler and auxiliary equipment

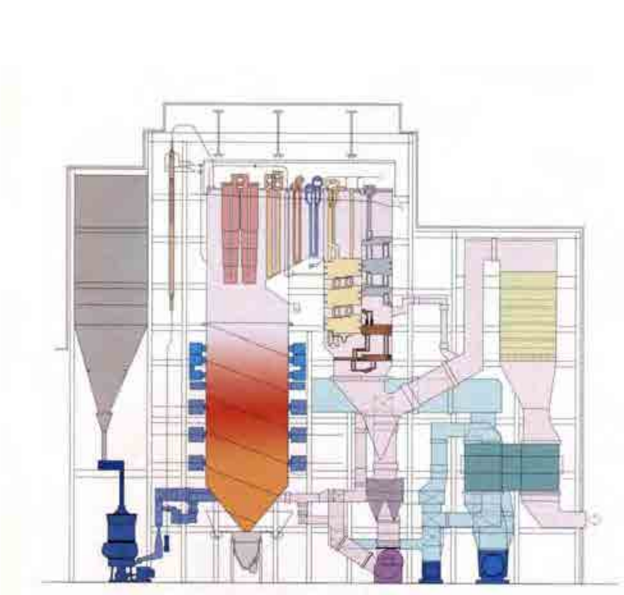
This clause explains only important major equipment. For individual equipments, a detailed explanation is described in clause 3.3 “Description of Power Plant Facility”.

(1) Boiler

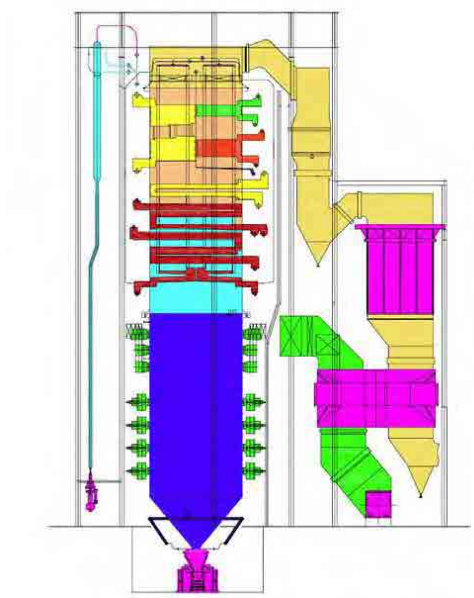
Boiler for Model Power Plant is as follows:

(a) Boiler shall employ USC steam condition, once through type and balanced draft.
(b) Boiler should be outdoor type with roof.
(c) Boiler should be designed to use Indonesian Low Rank Coal with direct firing.
(d) Supplementary fuel should be light oil. Supplementary fuel will be used for auxiliary boiler igniter of main burner, plant start up & shut down and flame stabilization purposes.

Figure. 3.1.4-1 shows illustrations of typical two types of USC boiler



Two pass Type



One pass type (Tower boiler)

Figure 3.1.4-1 Cross Section Diagrams for Typical USC Boiler.

Source: JICA study team

(2) Boiler auxiliary equipment

(Detailed descriptions are explained in clause 3.3 "Description of Power Plant Facility")

1) Coal supply and coal combustion system

Coal supply and coal combustion system include coal storage bunkers, coal feeders, coal pulverizes and coal burners.

(a) Coal pulverizer

Ring Roller type coal pulverizer should be applied for Model Power Plant.

For Coal pulverizer, it is important to secure a satisfactory fine-grain of coal, i.e. size of pulverized coal, if the coal has a high moisture content.

(b) Coal burner

Low NOx coal burner should be applied for Coal combustion system.

2) Forced Draft Fan (FDF) and Induced Draft Fan (IDF)

For FDF and IDF, axial fan with rotor blade variable pitch control should be applied.

3) Flue gas boost-up fan (BUF)

For BUF, axial fan with rotor blade variable pitch control should be applied.

3.1.5 Turbine and auxiliary equipment

(1) Steam turbine and auxiliaries

For steam turbine, there are two types of layout for Steam Turbine & Generator, one is Tandem Compound and another type is Cross Compound type. (Refer to Photo 3.1.5-1)

For Model Power Plant, Tandem Compound type should be applied.

(More details are described in clause 3.3 "Description for Power plant facilities".

Cross Compound type

Tandem Compound type

Photo 3.1.5-1 Typical large Capacity Steam Turbine

Source: JICA study team

3.1.6 Balance of plant (BOP)

BOP is the summary of all components and systems in a power plant, that are needed for harmonious, safe and efficient operation, such as a Dust collecting facility, Coal Handling system, Ash Handling system, DeSOx system, DeNOx system, Cooling Water system, Water Treatment system, Waste Water Treatment system and so on.

In this clause the important systems, facilities and equipment for a 1,000 MW power plant are explained.

(More details are described in clause 3.3 "Description for Power plant facilities".)

(1) Dust collecting system

Electrostatic Precipitator (ESP) or Fabric Filter should be applied for dust collector.

Dust concentration in flue gas and discharged from stack shall comply with environmental standard limit.

(2) Flue Gas Desulphurization system (FGD system)

Seawater type should be applied for FGD system. (Seawater FGD had applied for coal power plants in Indonesia.)

(3) DeNOx system

JICA study team assumes that DeNOx system is NOT necessary for Model Power Plant. The reason is because NO_2 concentration in flue gas, by using design coal, is approximately

350 mg/m^{3}N at boiler outlet. (However, please note that this NO_2 concentration usually depends on manufacturer's experience.)

(4) Water Treatment system

The water treatment system should consist of facilities for seawater filtration, desalination, demineralization, potable water treatment and water tank for Model Power Plant.

(5) Waste Water Treatment system

Waste Water Treatment system should be applied to Model Power Plant.

The quality of the water after treatment for waste water must comply with Indonesian waste water regulations.

(6) Coal Handling system

Coal handling system should be applied to Model Power Plant. Coal handling system shall include an unloading berth, unloading jetty, coal unloaders, coal receiving conveyers, coal storage yard, stackers/reclaimers, circulation conveyors and coal discharging conveyors to the coal storage bunker for Boiler.

Coal berth and jetty detail design should be taken into account both the economical aspect and environmental impact around Model Power Plant site area. And also environmental impact, caused by dredging of seabed for navigation canal for coal barge and coal vessel to berth, should be carefully considered.

(A detailed design of the berth, jetty and dredging should be carried out at the feasibility study stage.)

(7) Ash handling system

There are two kinds of ash produced by boiler, boiler bottom ash and fly ash.

For collecting bottom ash, a dry system should be applied. Dry bottom ash handling system is easier to operate and maintain than wet system. This is because the dry system doesn't use water for cooling bottom ash and increases boiler thermal efficiency slightly. Also, there is another advantage that dry bottom ash can be recycled at a coal mill, to become fine ash, i.e. fly ash. This bottom ash recycle system is an advanced technology.

For fly ash collecting system, a dry system should normally be applied. Collected fly ash should be transferred by a pneumatic system to a fly ash silo.

(8) Ash disposal area

Controlled landfill type ash disposal area should be applied and capacity of ash disposal area should be five years. (five years; PLN requirement) Capacity of ash disposal area is needed for life time of power plant; normally approximately 30 years, however, construction cost of ash disposal area has a large impact on power plant investment cost. On the other hand, fly ash and bottom ash can be utilized and sold for cement admixture and fertilizer admixture.

JICA study team applies an ash disposal area capacity of five years as PLN requested to reduce plant and investment costs. This disposal area will be used for the unsold fly ash and bottom ash.

(9) Cooling Water System

Cooling water system for turbine condenser should have a sea water intake, intake cannel or pipe, cooling water pump, intake screen, discharge pipe and outfall. The sea water intake location should be a deep layer and cold place. A detailed design should be carried out at the Feasibility Study stage.

For Cooling Water system, chlorine injection system of seawater electrolytic apparatus type and instrumentation should also be provided to detect residual chlorine for monitoring.

(10) Flue gas emission monitoring system

Flue gas emission monitoring system should be applied. And also remote environmental mortaring system for outside of Model Power Plant should be applied. Detail design of flue gas emission monitoring system and remote monitoring system should be studied at FS stage.

(11) Stack

Standalone type stack, with concrete outer casing and two inner stacks for flue gas, should be applied.

(12) Chlorination system for Cooling Water System

Hypochlorite system should apply to Cooling Water System which is an intake water pipe mouse. This is because there is a safety reason in the case of a leakage if hydrochloric (HCl) gas will use at Cooling Water System from HCl tank with pipe.

3.1.7 A consideration of each system unit capacity and numbers for standby unit

JICA study team recommends that main important equipment such as ID Fan, FD Fan, CW Pump, Condensate Pump, Boiler Feed water pump etc., should comprise of more than two units for each equipment for redundancy reasons. The number of standby units should be considered as follows.

- Single capacity of motor, fans and pumps have recently became larger and their reliability has also become better. Some equipment may cover 100% capacity of BMCR (Boiler Maximum Continuous Rating) and TMCR (Turbine Maximum Continuous Rating) in single units, however, Model Power Plant should NOT apply single units for reason of the reliability purpose.
- The number of standby equipment is also important for each system for design, since standby equipment affects EPC cost.
- Each detailed number of standby equipment design will be carried out at Feasibility Study stage.

3.1.8 A consideration of Equipment/Facilities/Building Division list

JICA study team recommends that Division of List for common facilities/Equipment/Building etc is as follows.

Phase-1 calls first 1,000 MW×1 unit (Year 2021) and Phase-2 calls 1,000 MW×1 unit (in the future)

Common facilities/Equipment/Building etc have to be installed in the Phase-1 stage because, it will save on construction costs for Phase-2. However, this will be a direct contract with same contractor of

Phase-1.

Table 3.1.8-1 Division for Model Power Plant

Division for Model Power Plant

LIST OF EQUIPMENTS		Phase 1 = Model Plant		Phase 2	
		Unit 1	Common	Unit 2	Remarks
NO.	DESCRIPTION				U1:for unit 1, U2:for unit 2
Equipment					
1	TURBINE & AUXILIARIES, TURBINE BUILDING	U1	-	U2	
2	BOILER & AUXILIARIES	U1	-	U2	
3	ENVIRONMENT PROTECTION SYSTEM (ESP, FDG)	U1	-	U2	
4	STACK (Inner stack)	U1&U2	-	- *	* Need to construct Unit 2 inner stack during Phase 1
5	EMERGENCY DIESEL GENERATOR	U1	-	U2	
6	AUXILIARY BOILER	U1	Common		
7	MAKE UP WATER TANK	U1	-	U2	
8	SWITCHYARD 500KV GIS	U1	Common	U2	
9	WATER TREATMENT PLANT WITH CHEMICAL TNAK AND DEMINERAL WATER TANK	U1	-	U2	
10	DESALINATION PLANT	U1	-	U2	
11	PORTABLE WATER SYSTEM/PLANT AND WATER TANK				
12	COAL UNLOADER	U1	Common*	U2	Common:Rail, Monitoring/control room. Equipment will be installed sepalatery.
13	STACKER / RECLAIMER	U1	Common*	U2	
14	COAL RECEIVING CONVEYOR	U1	-	U2	
15	COAL RECEIVING CONVEYOR TRESTLE	-	Common	-	
16	FLY ASH SILO	U1	-	U2	
17	COOLING WATER INTAKE STRUCTURE (Including Chlorination system)	U1	Common	U2	
18	COMPRESSOR	U1	Common	U2	
19	COAL HANDLING TRANSFER TOWER	U1	Common	U2	
Yard & Ash Pond					
1	COAL STORAGE YARD (INDOOR TYPE FOR 7 DAYS AND OUT DOOR TYPE FOR 30 D	U1	-	U2	
2	ASH DISPOSAL YARD	-	Common	-	
3	COAL YARD SEDIMENTATION POND	-	Common	-	
4	ASH DISPOSAL YARD RUNOFF POND	-	Common	-	
Common facilities					
1	COAL UNLOADING JETTY	-	Common	-	
2	STACK (Outer Structure)	-	Common	-	
3	WASTE WATER TREATMENT PLANT	-	Common	-	
4	FUEL OIL TANK	-	Common	-	
5	SERVICE / FIRE WATER TANK	-	Common	-	
6	LUBRICATION OIL STORAGE TANK	-	Common	-	
7	COAL YARD SEDIMENTATION POND AND WASTE WATER TREATMENT PLANT	-	Common	-	
8	ASH YARD RUNOFF WASTE WATER TREATMENT PLANT	-	Common	-	
Building, House & Room					
1	SWITCHINGYARD CONTROL BUILDING	-	Common	-	
2	ELECTROCHLORINATION SYSTEM HOUSE	-	Common	-	
3	CENTRAL CONTROL BUILDING	-	Common	-	
4	ADMINISTRATION BUILDING	-	Common	-	
5	COOLING WATER PUMP HOUSE	-	Common	-	
6	WASTE WATER TREATMENT PLANT CONTROL BUILDING		Common		
7	COAL HANDLING ELECTRICAL AND CONTROL HOUSE	-	Common	-	
8	COAL CRUSHING HOUSE	-	Common	-	
9	ASH HANDLING ELECTRICAL HOUSE	-	Common	-	
10	FIRE PUMP HOUSE AND ELECTRICAL ROOM	-	Common	-	
11	CEMS (CONTINIOUS ENVIRONMENTAL MONITORING SYSTEM) ROOM	-	Common	-	
12	COAL UNLOADING JETTY ELECTRICAL HOUSE	-	Common	-	
13	COAL STORAGE YARD ELECTRICAL HOUSE	-	Common	-	
14	FGD ELECTRICAL HOUSE	-	Common	-	
15	WORK SHOP	-	Common	-	
16	WAREHOUSE	-	Common	-	
17	BULLDOZER HOUSE		Common		
18	FIRE-FIGHTING VEHICLE AND AMBULANCE HOUSE		Common		
19	PR HOUSE		Common		
20	CANTEEN		Common		
21	GATE HOUSE	-	Common	-	
22	PARKING & GARAGE (AMBULANCE / FIRE FIGHTING TRUCK etc.)	-	Common	-	

Source: JICA Study team

3.2 Environmental Laws and Regulations

Design of Model Power Plant should comply with Environmental laws and regulations in Indonesia and IFC EHS guideline for reference.

Continious Emission Monitoring System (CEMS) should be applied for Model Power Plant. Then Model Power Plant must comply with Standard Limit of Emission for Thermal Power Plant Fix Sources (CEMS Technology) shown in Table 3.2.3-1.

3.2.1 Ambient Air Quality limit (Indonesia)

Table 3.2.1-1 Standard Limit of Air Quality/Emission and Ambient

No.	Parameter (time measurement)	Unit	Limit	Metoda/Alat
1	Sulfur Dioksida (SO_2)			
	(1 hour)	μg/Nm^3	900	Pararosanilin
	(24 hour)	μg/Nm^3	365	Pararosanilin
	(1 year)	μg/Nm^3	60	Pararosanilin
2	Nitrogen Dioksida (NO_2)			
	(1 hour)	μg/Nm^3	400	Saltzman
	(24 hour)	μg/Nm^3	150	Saltzman
	(1 year)	μg/Nm^3	100	Saltzman
3	Carbon Monoksida (CO)			
	(1 hour)	μg/Nm^3	30	NDIR
	(24 hour)	μg/Nm^3	10	NDIR
	(1 year)	μg/Nm^3	-	NDIR
4	Hidrocarbon(HC)*(3 hours)*	μg/Nm^3	160	GC / Flame Ionization
5	Oxsidants (O_3)			
	(1 hour)	μg/Nm^3	235	Chemiluminescent
	(1 year)	μg/Nm^3	50	Chemiluminescent
6	Dust (TSP) *(24 hours)*	μg/Nm^3	230	Gravimetric
	(1 year)	μg/Nm^3	90	Gravimetric
7	Pb *(24 hours)*	μg/Nm^3	2	Gravimetric
	(1 year)	μg/Nm^3	1	Gravimetric
8	PM_{10} *(24 hours)*	μg/Nm^3	150	Gravimetric
	$PM_{2.5}$ *(24 hours)*	μg/Nm^3	65	Gravimetric
	(1 year)	μg/Nm^3	15	Gravimetric
9	Dustfall			
	On settlement (30 days)	Tons/km^2	10	Gravimetric
	On industry (30 days)	Tons/km^2	20	Gravimetric
10	Total Fluorides (as F)			
	(24 hours)	μg/Nm^3	3	Specific Ion
	(90 days)	μg/Nm^3	0.5	Electrode
11	Fluor Index *(30 days)*	40 cm^2 of limited filter paper	100	Colourimetric
12	Khlorine & *(24 hours)*	μg/Nm^3	150	Specific Ion
	Khlorine Dioxide *(24 hours)*	μg/Nm^3		Electrode
13	Index Sulphat *(30 days)*	Mg SO_3/100 cm$_3$	1	Colourimetric
		Of lead peroxide		Peroxide Candle

Source: No. 10 through 13 only coming into force for the area/region of Chemical Industry Base (example : Petro Chemical Industry, Preparation of sulfuric acid industry)
- Government Regulation No. 41 Year 1999

3.2.2 Emission Limit for Thermal Power Plant of Fix Source (Indonesia)
(No Continious Emission Monitoring System (CEMS) Technology)

Table 3.2.2-1 Standard Limit of Emission for Thermal Power Plant of Fix Source (without CEMS Technology)

No	Parameters	Maximum Standard limit (mg/Nm^3)		
		Coal	Oil	Gas
1	Sulfur Dioxide (SO_2)	750	1,500	150
2	Nitrogen Oxide (NOx) representing by NO_2	850	800	400
3	Total Particulate	150	150	50
4	Opacities	20%	20%	

Source: Ministerial of Environment Regulation No. 21/2008 regarding Emission Limit for Thermal Powel Plant (Annex 1a)

Gas volume is measured at standard conditions (temperature 25.0ºC and pressure 1 atmosphere)

1. Opacities is used as a practical monitoring indicator.
2. All parameters are corrected with O_2 as much as 7% for coal in dried except opacities.
3. All parameters are corrected with O_2 as much as 5% for oil in dried except opacities.
4. All parameters are corrected with O_2 as much as 3% for gas in dried except opacities.
5. All the emission limit for 95% of operational time for at least three days.

3.2.3 Emission Gas Standard for Thermal Power Plant of Fix Source using (Indonesia)
(with CEMS Technology)

Table 3.2.3-1 Standard Limit of Emission for Thermal Power Plant Fix Sources (with CEMS Technology)

No.	Parameters	Maximum Standard limit (mg/Nm3)		
		Coal	Oil	Gas
1	Sulfur Dioxide (SO_2)	750	650	50
2	Nitrogen Oxide (NOx) representing by NO_2	750	450	320
3	Total Particulate	100	100	30
4	Opacities	20%	20%	

Source: Ministerial Environment Regulation No. 21/2008, regarding Emission Limit for thermal Power Plant (Annex 1b)

- Gas volume is measured at standard conditions (temperature 25.0ºC and pressure one atmosphere).
- Opacities are used as practical monitoring indicator.
- All parameters are corrected with O_2 as much as 7% for coal except in dried opacities.
- All parameters are corrected with O_2 as much as 5% for oil except in dried opacities.
- All parameters are corrected with O_2 as much as 3% for gas except in dried opacities.
- All emission limits for 95% of operational time for at least three days.

3.2.4 Emission Gas Standard for Thermal Power Plant in Jakarta

(For your information, this standard should not to be applied to Model Power Plant)

Table 3.2.4-1 Standard Limit of Emission Gas for Thermal Power Plant in Jakarta Based on Governor Decree

No.	Parameter	Maximum Limit (mg/m^3)
1.	Total Particle	150
2.	Sulfur Dioxide (SO_2)	750
3.	Nitrogen Oxide (NOx)	850
4.	Opacity	20%

Source: Annex 2, the Decree of Jakarta Governor No. 670 Year 2000 regarding the Emission Gas Standard from Fix Sources

3.2.5 Jakarta Ambient Air Standard

(For your information, this standard should not to be applied to Model Power Plant))

Table 3.2.5-1 Ambient Air Quality Standard Based on Provincial Regulation

No.	Parameter	Measurement Time	Quality Standard
1.	Sulfur Dioxide (SO_2)	1 Hour 24 Hours 1 Year	900 ug/Nm^3 (0.34 ppm) 260 ug/Nm^3 (0.1 ppm) 60 ug/Nm^3 (0.02 ppm)
2.	Carbon Monoxide (CO)	1 hour 24 hours	26.000 ug/Nm^3 (23 ppm) 9.000 ug/Nm^3 (8 ppm)
3.	Nitrogen Dioxide (NO_2)	1 Hour 24 Hours 1 Year	400 ug/Nm^3 (0.2 ppm) 92,5 ug/Nm^3 (0.05 ppm) 60 ug/Nm^3 (0.003 ppm)
4.	Oxidant (O_3)	1 hour 1 year	200 ug/Nm^3 (0.05 ppm) 30 ug/Nm^3 (0.015 ppm)
5.	Hidrocarbon (HC)	3 hours	160 ug/Nm^3 (0.24 ppm)
6.	Particle < 10 urn (Pmio)	24 hours	150 ug/Nm^3
7.	Particle < 2.5 um ($PM_{2,5}$)	24 hours 1 year	65 ug/Nm^3 15 ug/Nm^3
8.	Dust (TSP)	24 hours 1 year	230 ug/Nm^3 90 ug/Nm^3
9.	Plumbum (Pb)	24 hours 1 year	2 ug/Nm^3 1 ug/Nm^3

Source: Annex 1 of The Decree of Jakarta Governor Decree No. 551 year 2001 regarding Ambient Air and Noise Level Standard for Jakarta

3.2.6 Wastewater Standard for Thermal Power Plant

(1) Liquid/Waste Water Limit for Thermal Power Plant

1) Central Processing

Table 3.2.6-1 Standard Limit of Liquid/Waste Water for Central Processing Unit of Thermal Power Plant

No	Parameters	Unit	Limit
1	pH	-	6-9
2	TSS	mg/L	100
3	Fat and oil	mg/L	10
4	Free Chlorine (Cl_2)	mg/L	0.5
5	Total Chromium (Cr)	mg/L	0.5
6	Copper (Cu)	mg/L	1
7	Iron (Fe)	mg/L	3
8	Zinc (Zn)	mg/L	1
9	Phosphate (PO^{4-})	mg/L	10

Source: Ministerial Environment Regulation No. 8 Year 2009 (annex 1)
In the case blow-down water from cooling does not lead to IPAL, phosphate is injected.

Table 3.2.6-2 Standard Limit of Liquid/Waste Water for Blow-Down Boiler of Central Processing Unit of Thermal Power Plant

No	Parameters	Unit	Limit
1	pH	-	6-9
2	Copper (Cu)	mg/L	1
3	Iron (Fe)	mg/L	3

Source: Ministerial Environment Regulation No. 8 Year 2009 (annex 1)
In this case, blow-down water from boiler does not lead to IPAL.

Table 3.2.6-3 Standard Limit of Liquid/Waste Water for Blow-Down Cooling Tower of Central Processing Unit of Thermal Power Plant

No.	Parameters	Unit	Limit
1	pH	-	6-9
2	Free Chlorine (Cl_2)	mg/L	1
3	Zinc (Zn)	mg/L	1

Source: Ministerial Environment Regulation No. 8 Year 2009 (annex 1)
In this case, blow-down water from cooling tower does not lead to IPAL.

Table 3.2.6-4 Standard Limit of Liquid/Waste Water for Demineralization/WTP of Central Processing Unit

No	Parameters	Unit	Limit
1	pH	-	6-9
2	TSS	mg/L	100

Source: Ministerial Environment Regulation No. 8 Year 2009 (annex 1)
In this case, demineralization/WTP does not lead to IPAL.

2) Supporting Unit

Table 3.2.6-5 Standard Limit of Liquid/Waste Water for Cooling Water

No	Parameters	Unit	Limit
1	Temperature	°C	40
2	Free Chlorine (Cl_2)	mg/L	0.5

Source: Ministerial Environment Regulation No. 8 Year 2009 (annex 2)
In this case, Cooling Tower does not lead to IPAL

Table 3.2.6-6 Standard Limit of Liquid/ Waste Water for Desalination

No	Parameters	Unit	Limit
1	pH	-	6-9
2	Salination	-	Within 30 m from the location of exile waste water to the sea, the salinity of waste water shall remain the same as natural salinity of the sea water.

Source: Ministerial Environment Regulation No. 8 Year 2009 (annex 2)
In this case, Desalination does not lead to IPAL

Table 3.2.6-7 Standard Limed of Liquid/Waste Water for FGD System (Sea Water Wet Scrubber)

No.	Parameters	Unit	Limit
1	pH	-	6-9
2	SO_4(2-)	%	The maximum increasing of the sulfate inlet sea water not more then 4%

Source: Ministerial Environment Regulation No. 8 Year 2009 (annex 2)
In this case, FGD (Sea Water Wet Scrubber does not lead to IPAL)

3) Coal Stock Pile

Table 3.2.6-8 Standard Limit of Liquid/Waste Water for Coal Stockpile

No.	Parameters	Unit	Limit
1	pH	-	6-9
2	TSS	mg/L	100
3	Fe	mg/L	5
4	Mn	mg/L	2

Source: Ministerial Environment Regulation No. 8 Year 2009 (annex 2)
In this case, Coal Stockpile boiler does not lead to IPAL.

4) Oily Water

Table 3.2.6-9 Standard Limit of Liquid/Waste Water for Oily Water

No.	Parameters	Unit	Limit
1	COD	mg/L	300
2	TOC	mg/L	110
3	Fat and Oil	mg/L	15

Note: Ministerial Environment Regulation No. 8 Year 2009 (annex 3)
In this case, Oily Water does not lead to IPAL

3.2.7 Noise Standard Limit

Table 3.2.7-1 Standard Limit for Noise

Land Utilization Type/Activity Environment	Level of Noise db (A)
A. Land Utilization Type	
1. Housing Complex and Settlement	55
2. Trade and Service Center	70
3. Office and Trade Area	65
4. Industrial Area	50
5. Government and Public Facility	60
6. Recreation Area	70
7. Specific Area:	
- Airport	
- Railway Station	60
- Sea Port	70
- Cultural Heritage	
B. Activity Environment	
1. Hospital	55
2. School	55
3. Religion Facility	55

Source: The Decree of State Ministry of Environment No. 48 Year 1996

3.2.8 Standard Limit of Vibration

(1) Pleasant and Healthy Vibration Standard Limit

Table 3.2.8-1 Pleasant and Healthy Vibration Standard Limit

Frequent (Hz)	Value of Vibration level in micron (10^{-6} meter)			
	Annoting (sometimes)	Annoying	Unpleasant	Unhealthy
4	< 100	100 - 500	> 500 - 1,000	> 1,000
5	< 80	80 - 350	> 350 - 1,000	> 1,000
6,3	< 70	70 - 275	> 275 - 1,000	> 1,000
8	< 50	50 - 160	> 160 - 500	> 500
10	< 37	37 - 120	> 120 - 300	> 300
12,5	< 32	32 - 90	> 90 - 220	> 220
16	< 25	25 - 60	> 60 - 120	> 120
20	< 20	20 - 40	> 40 - 85	> 85
25	< 7	17 - 30	> 30 - 50	> 50
31,5	< 2	12 - 20	> 20 - 30	> 30
40	< 9	9 - 15	> 15 - 20	> 20
50	< 8	8 - 12	> 12 - 15	> 15
63	< 6	6 - 9	> 9 - 12	> 12

Source: The Decree of State Ministry Environment No 49 Year 1996 (annex 1)

3.2.9 Standard Limit of Mechanical Vibration Based on Impact of Damage

Table 3.2.9-1 Standard limit of Mechanical Vibration by Type of Building

Class of the Building	Type of Building	Vibration Speed (mm/second)			
		At Foundation of the Building			In the Flat Floor of Upper level
		Frequency			
		< 10 Hz	10 15 Hz	50 - 100 Hz	Mixed Frequency
1	Trade and Industrial Building	< 10 Hz	20 - 40	40 - 50	40
2	Housing and Similiar used building	5	5 - 15	15 - 20	15
3	Structures sensitive to vibration, unlike those in No.1 and 2, which have a high cultural value (such as preserved buildings)	3	3 - 8	8 - 10	8,5

Source: The Decree of State Ministry Environment No 49/1996 (annex 3)

3.2.10 Standard Limit of Shock Vibration

Table 3.2.10-1 Standard Limit of Shock Vibration

Class	Type of Building	Vibration Speed (mm/second)
1.	Heritage and historical Building	2
2.	Building with minor damage	5
3.	Building with less damage	10
4.	Strong Building	10-40

Source: The Decree of State Ministry Environment No 49 Year 1996 (annex 4)

3.2.11 Standard Limit of Odor

(1) Single Odor

Table 3.2.11-1 The Standard Limit of Single Odor

No	Parameter	Limit	Unit	Method	Equipment Used
1	Ammonia (NH3)	ppm	2	Indophenol Methods	Spectrophotometer
2	Methyl Mercaptane	ppm	0.002	Absorption Gas	Gas Chromatograph
3	Hydrogen Sulfide	ppm	0.02	Mercury Tiosinate Absorption Gas	Spectrophotometer Gas Chromatograph
4	Methyl Sulfide	ppm	0.01	Absorption Gas	Gas Chromatograph
5	Styrene	ppm	0.1	Absorption Gas	Gas Chromatograph

Note: ppm = parts per million

Source: The Decree of State Ministry of Environment No 50/MNLH/09 Year 1996

(2) Mixed Odor

The odor level, which comes from a mixed odor, is determined through sensor detection by more than 50% of the EIA members or at least eight members/person.

3.2.12 Codes and Standards

Design of power plant, manufacturer's works, installation, tests and commissioning should be done in accordance with applicable internationally recognized codes and standards and Indonesian codes and standards. The full names of the internationally recognized codes and standards are:

Table 3.2.12-1 Internationally Recognized Codes and Standards

Abbreviation	Name
AABC	Associated Air Balance Council
ABMA	The American Bearing Manufacturers Association
ACI	American Concrete Institute
ADC	Air Diffusion Council
AGMA	American Gear Manufacturers Association
AIJ	Architectural Institute of Japan
AISC	American Institute of Steel Construction, Inc.
AISE	Association of Iron and Steel Engineers
AISI	American Iron and Steel Institute
AMCA	Air Movement and Control Association International, Inc.
ANSI	American National Standards Institute
API	American Petroleum Institute
ARI	Air Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
BS	British Standard
CEIAC	Coastal Engineering Defense Information Analysis Center
CGA	Compressed Gas Association
CMAA	Crane Manufacturers Association of America
DIN	German Institute for Standardization
EN	European Committee for Standardization
FED SPEC	Federal Specifications, Standards and Commercial Item Descriptions
FM	Factory Mutual Insurance Co.
HEI	Heat Exchange Institute
HIS	Hydraulic Institute Standards
HMI	Hoists Manufacturer's Institute
ICEA	Insulated Cable Engineers Association
IEC	International Electro technical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISA	Instrument Society of America
ISO	The International Organization for Standardization
JASS	Japanese Architectural Standard Specification
JIS	Japan Industrial Standard
MBMA	Metal Building Manufacturers Association, USA
MSS	Manufacturers Standardization Society of The Valve and Fitting Industry, Inc.
NAAMM	National Association of Architectural Metal Manufacturers
NACE	National Association of Corrosion Engineers
NBS	National Bureau of Standards, USA
NEBB	National Environmental-Balancing Bureau
NEMA	National Electrical Manufacturers Association
NERC	North American Electric Reliability Council
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Act
SAE	Society of Automotive Engineers, USA
SSPC	Structural Steel Painting Council

Source: JICA Study Team

3.3 Description of Power Plant Facility

Basically, most of USC power plant systems and facilities have a very similar structure to a super critical power plant. So, this part will explain the major system of USC and major important facilities such as the boiler, coal pulverizer for lignite, dust collector, coal handling system, ash handling system, ash disposal area, DeSOx system, DeNOx system, steam turbine and cooling water system. Detailed descriptions of the other systems and facilities of will be carried out at FS stage.

3.3.1 Boiler and Auxiliaries

(1) Boiler configurations

JICA study team applies the following boiler configurations to Model Power Plant.

Type	Supercritical one through sliding (variable) pressure reheat type
Boiler maximum continuous rating (BMCR)	Approx.3,100 t/h
Steam condition	25.4MPa/605°C /623°C at boiler outlet
Furnace type	Two path or Tower type
Furnace wall type	Spiral wall with plain tube or Vertical wall with ribbed tube membrane
Start-up system	High pressure turbine bypass system
Burner arrangement	Opposed or Tangential
Mill type	Ring roller mill
Primary air system	Cold air system
Air heater type	Tri-sector, regenerative rotating
Draft system	Balance draft system
Electrostatic Precipitator	4 ESP sets with 2 parallel paths each
Ash disposal system	Dry extraction and disposal

1) Type of Boiler

JICA study team studied drum-type and once-through-type boiler in comparison and found the following:

a) Two path/Tower type

Furnace configuration is derived from each plant manufacturer’s specialty, and the two-path type is the norm in Japan. On the other hand, the tower type is commonly used in Europe.

No significant difference with two types of boiler were observed in the applicability for coal characteristics. This is because the boiler design can be adjusted in accordance with coal characteristics (such as ash abrasion).

b) Constant Pressure / Sliding (Variable) Pressure Type

Supercritical boilers can be classified into two basic design categories according to their operating-pressure regimes. For units designed for constant pressure operation, supercritical pressures are maintained in both furnace walls and superheater over the normal operating range. This type is suitable for the base load mode thermal power plant.

On the other hand, for the unit design with full sliding (variable) pressure, the furnace walls and superheater pressures may vary with load, including operation at subcritical pressure. This type is desirable for the middle load mode thermal power plant.

Pressure program and fluid diagram of both types of constant pressure and sliding (variable) are shown in Figure 3.3.1-1, 2 and Figure 3.3.1-3, 4 respectively.

Boiler manufacturers have developed their own fluid circulation systems, and C-E type system is adopted in this report as a typical example.

Constant pressure circulation system consists of the recirculating pump, water separator and associated valves as shown in Figure 3.3.1-1 and 3.3.1-2. The fluid system is kept as high as rated pressure from the initial stage to full load. The required minimum water flow is maintained by running the recirculating pump, and low-pressure steam from the separator is led to the steam turbine for warming. Along with the rise of turbine load afterwards, the recirculating pump is stopped and a once-through operation starts.

On the other hand, sliding (variable) pressure type is equipped with recirculating pump, water separator, drains system and associated valves similar to constant pressure type as shown in Figure 3.3.1-3.

For start up and low load operation below 30%, the unit utilizes pump recirculation system to provide an adequate mass flow through the furnace wall tubes.

This once-through design eliminates the boiler throttling valves and adopts a full sliding (variable) pressure approach (Figure 3.3.1-4). The furnace walls are allowed to enter the subcritical pressure range along with the superheater circuits by means of using the spiral structure of water wall tube or rifled tube for vertical water wall. Then supercritical pressure operation begins in the higher load range as shown.

Sliding (variable) pressure type is recommended from the diversity of operation; however a 30-year operation mode should be examined about Model Power Plant in detail in the future, and a selection of either the constant pressure type or the sliding (variable) pressure type should be decided.

c) **Spiral (plain/bare tube) Wall and Vertical (rifled/ribbed tube) Wall Type**

Both furnace configurations are shown in Figure 3.3.1-5.

The principal concern with a sliding (variable)-pressure supercritical pressure design is the requirement for a once-through operation. The mass flow in the furnace-wall tubes must be sufficiently high to avoid overheating or departure from nucleate boiling (DNB) while generating steam is at subcritical pressures, and to avoid excessive metal temperatures and uneven steam outlet temperatures when the plant is operated at supercritical pressure at higher boiler loads.

To accomplish these objectives, the spiral-wall design is used for the units. The principle of the spiral or helical-wall furnace is to increase the mass flow per tube by reducing the number of tubes needed to envelop the furnace without increasing the spacing between the tubes. This is done by arranging the tubes at an angle and spiraling them around the furnace. For instance, the number of tubes required to cover the furnace wall can be reduced to one half by putting the tubes at a 30 degree angle (Figure 3.3.1-6). Note that the centerline spacing or pitch (P) is made the same as a vertical wall to prevent fin overheating. Additionally, by spiraling around the furnace, every tube is part of all the walls, which means that each tube acts as a heat integrator around the four walls of the combustion chamber.

The spiral-wall concept thus addresses two major challenges of the full-sliding (variable) pressure supercritical pressure boiler:

- Achieving the required mass flows to avoid overheating and excessive metal temperatures by reducing the number of tube circuits
- Minimize differences in tube-to-tube heat absorption by exposing each tube to all four furnace walls

Spiral-wall furnaces have been in operation in Europe and Japan for many years and have given satisfactory performances.

As an alternative to the spiral-wall design for larger-size steam generators, a certain manufacturer offers a tangentially fired unit with vertical walls consisting of rifled tubes for ease of fabrication, erection, and maintenance. A stable fireball is formed in the center of the furnace with tangential firing, with essentially equal distribution of the lateral heat absorption on all furnace walls. Unbalances are minimized and lateral heat-absorption patterns are predictable over the entire load range. Rifled tubing is used in the furnace walls to avoid overheating or DNB at subcritical pressures.

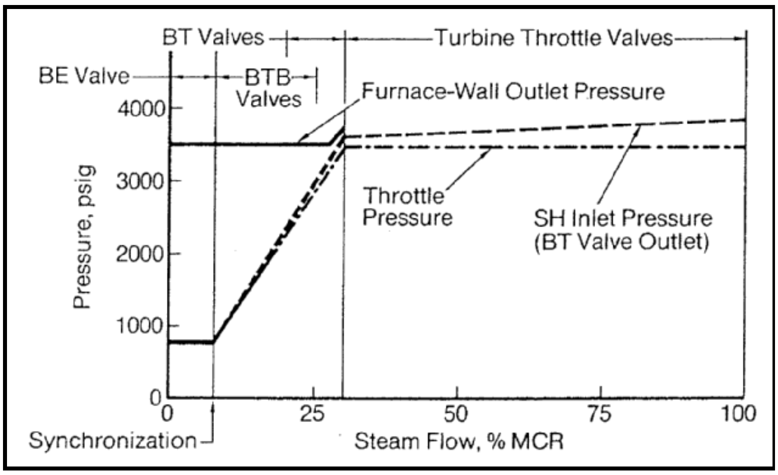


Figure 3.3.1-1 Constant Pressure Program for C-E Type

Source: JICA study team

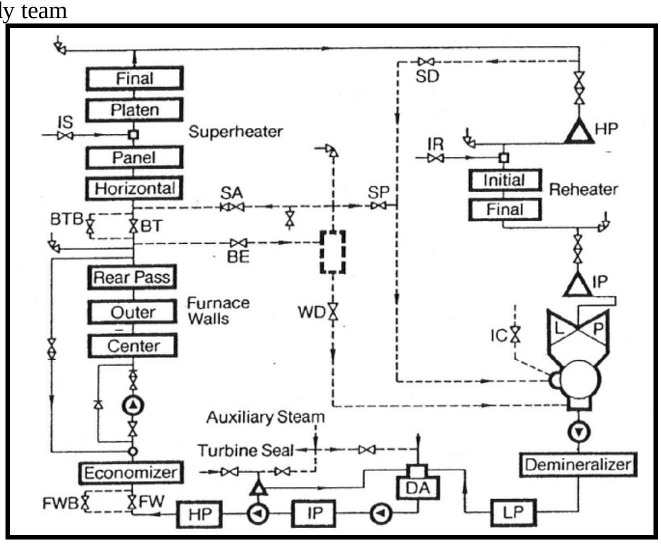


Figure 3.3.1-2 Constant Pressure Diagram of C-E Type

Source: JICA study team

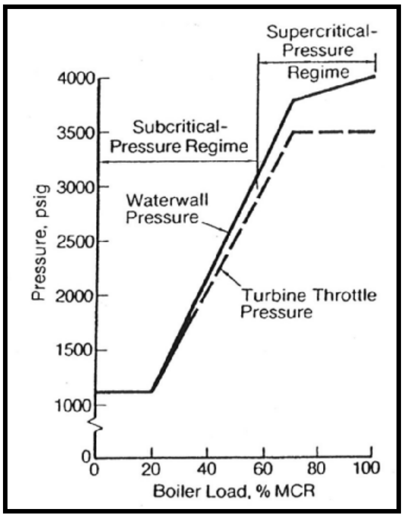


Figure 3.3.1-3 Sliding (Variable) Pressure Program for C-E Type

Source: JICA study team

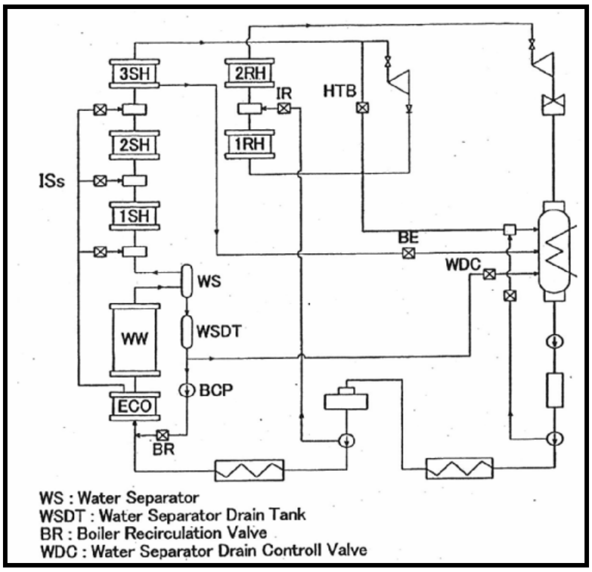


Figure 3.3.1-4 Sliding (Variable) Pressure Diagram of C-E Type

Source: JICA study team

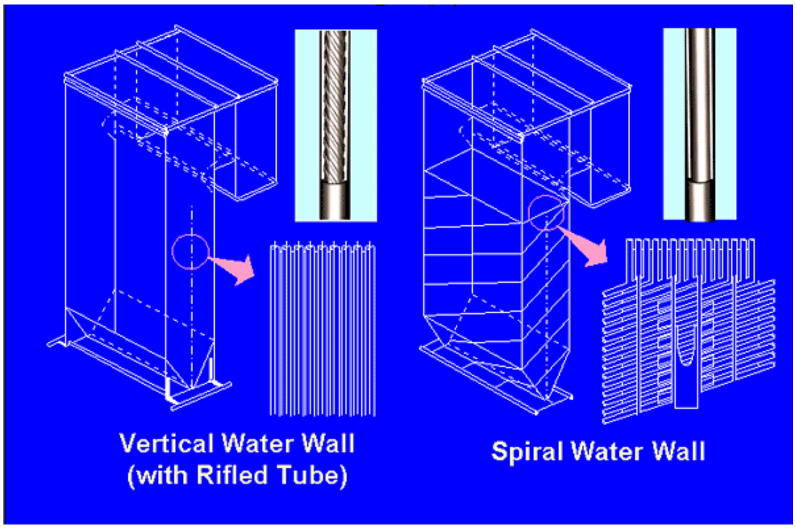


Figure 3.3.1-5 Furnace Configuration

Source: JICA study team

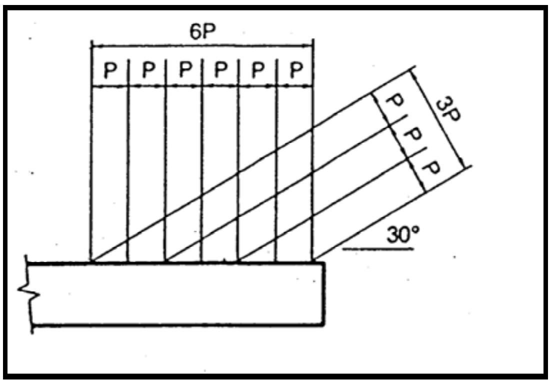


Figure 3.3.1-6 Basic Principle of Spiral-wall Furnace

Source: JICA study team

d) Material Selection

The materials in high temperature part in the boilers corresponding to the steam parameters are shown in Table 3.3.1-1. These materials are conformed to the international standard such as ASME and JIS, though superior materials are adopted along with allowing high steam temperature. The boiler materials recommended for Model Power Plant are shown in Table 3.3.1-1 below. These materials have been used for 10 years or more in the coal fired USC units in Japan, and it is evaluated and proven that they are highly reliable materials. Table 3.3.1-1 shows the typical material selection in boiler pressure parts. This material application shows the basic design and each manufacturer has own criteria considering the manufacturer's design.

Table 3.3.1-1 Definition of USC Boiler

Classify	Pressure	Temp	Material (typical example)	Boiler type
Sub Critical	Lower than Critical P< 22.06 MPa	MST:≦566°C RST: ≦566°C	Pipe: P22 Tube: T22,TP321H,TP347HFG	Drum or Once-Through
Super Critical	Super Critical pressure P> 22.06 MPa	MST:≤538°C RST:≤566°C	Pipe: P22/P91 Tube: TP321H,TP347HFG, Super 304H	Once-Through
Ultra Super Critical (USC)		MST: > 566°C RST: > 593°C	Pipe: P91/P92 Tube:Super 304H, HR3C	Once-Through

Source: JICA study team

Table 3.3.1-2 Experience of Thermal Efficiency and Steam Parameter for recent Coal Fired Power Plant

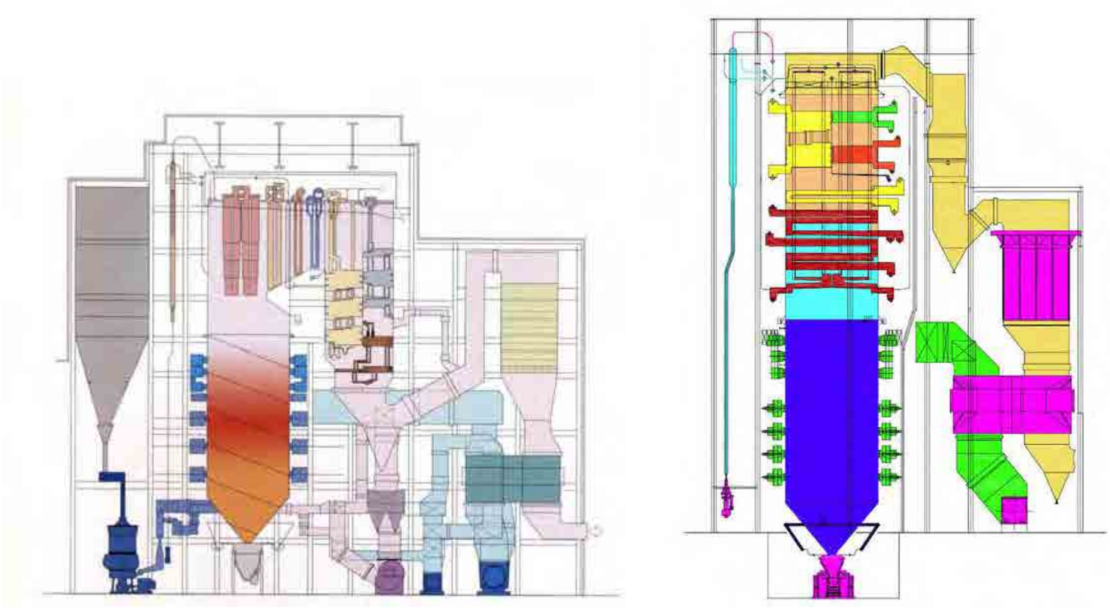
Case. No.	Steam Parameters at Turbine inlet		Plant efficiency (%)	Increase in efficiency (%)	Cumulative increase in efficiency (%)
	MST (kg/cm^2)	MST/RST (ºC/ ºC)			
1. USC-1	246	566/593	42.08	Base	Base
2. USC-2	246	593/593	42.38	0.30	0.3
3. USC-3	256	600/610	42.78	0.40	0.70
4. USC-4	256	600/620	42.88	0.10	0.80

Source: JICA study team

Note: Above table of steam condition, plant efficiency, etc. are based on Bituminous and sub-bituminous coal firing power plant.

The Lignite coal fired power plant efficiency will be decreased 2 to 3% from the above figures of table.

A typical USC boiler is as follows:



Two pass **Tower boiler**

Figure 3.3.1-7 Cross Section Diagrams for Typical USC Boiler.

Source: JICA study team

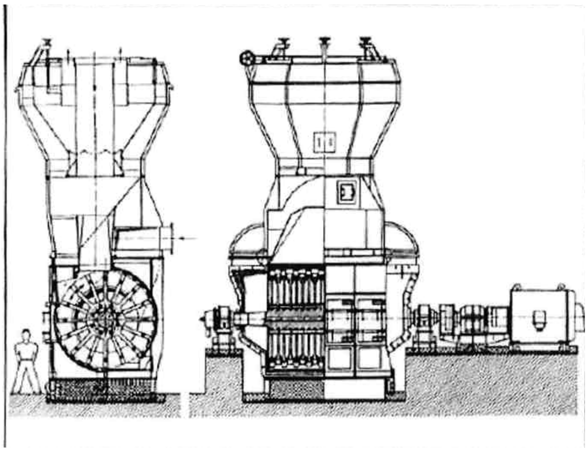
(2) Pulverizer

Ring roll mill shall be applied to Model Power Plant, based on comparison of pulverizer shown in Table 3.3.1-3. The design for the capacity of mill and the numbers of mill should be examined more at Feasibility Study stage. Descriptions and technical comparisons of each pulverizer are as follows:

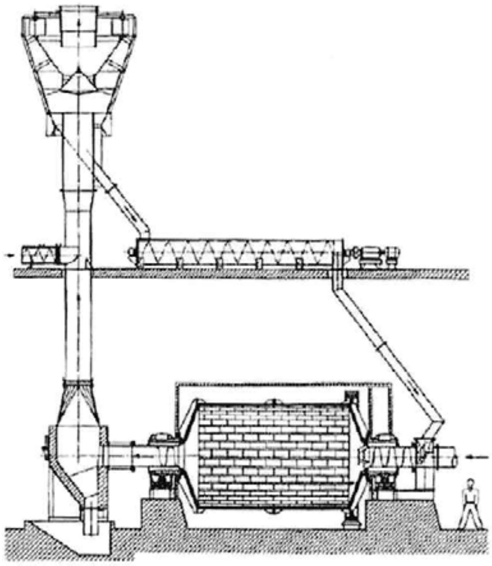
Table 3.3.1-3 Descriptions and comparison of each pulverizer

Item	Bitter Mill (Hammer Mill)	Tube Mill	Ring Roller Mill	Bitter Fan Mill
Category of Mill	Impact Mill	horizontal type Tube Mill (Ball Mil)	Vertical type mill (Baul Mill)	
Outside shape	Medium	Large	Small	Large
Setup space	Medium	Large	Small	Large
Refined ratio of pulverized coal	The control range of the ratio of refined coal is wide	Finely pulverized coal is a strong point	Finely pulverized coal is a strong point	It is not easy to grind coal finely
Handling ratio for Hard/Soft coal	Soft coal to little hard coal	Soft coal to very hard coal	Soft coal to hard coal	Soft coal only
Handling ratio for Moisture	The control range of the moisture ratio of coal is wide	The control range of the moisture ratio of coal is wider.	Not good for high moisture coal	Not good for too much extremely wet coal
Handling ratio for exogenous material	Weak	Strong	Base	Weak
Power consumption ratio	Medium	Large	Small	Medium
Dynamic characteristics	Good	Slow	Good	Good
Maintainability	Good	Good	Base	Base
Possibility for large capacity	Difficult	Easy	Easy	8 units for 1,000 MW experience
Typical Mill	HS-Mill (DBW) GS-Mill (DBW)	DBW-Tube Mill MHI-Tube Mill IHI-Ball Mill Ube-Tube Mill	E-Mill (B&W/DBW/BHK) MB-Mill (VKW/FW) MBF-Mill (FW/IHI) MPS-Mill (DBW/BHK/KHI) Leimond-Mill (CE/MHI) IHI-VS-Mill MHI-MRS-Mill Hitachi-MPS-Mill	DGS-Mill (DBW)
Remarks	It is good for CFBC coal pretreatment	It is not good for use when there is lots of volatile coal matter because there is a lot of coal inside	The most advanced pulverizer. This type of mill is most popular	It is good for lignite coal use. (Less than 2,600kcal coal)

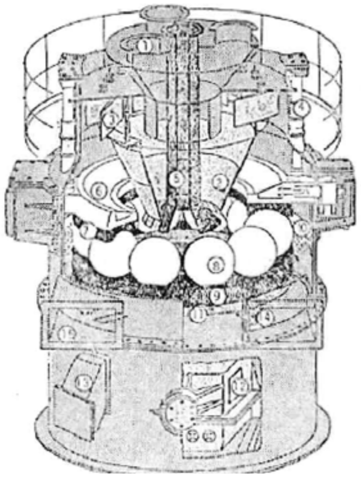
Source: JICA study team



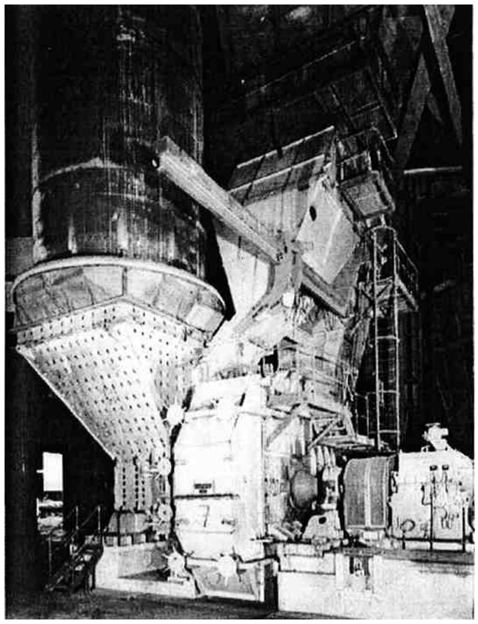
Impact Mill



Tube Mill



Large size Roller Mill



Bitter Fan Mill

Figure 3.3.1-8 Typical type of Mill

Source: JICA study team

(3) Coal Burner

JICA study team applies Low NOx coal burner to model power plant.

Also, the two stage combustion method shall be adopted for NO_2 reduction to Model Power Plant boiler.

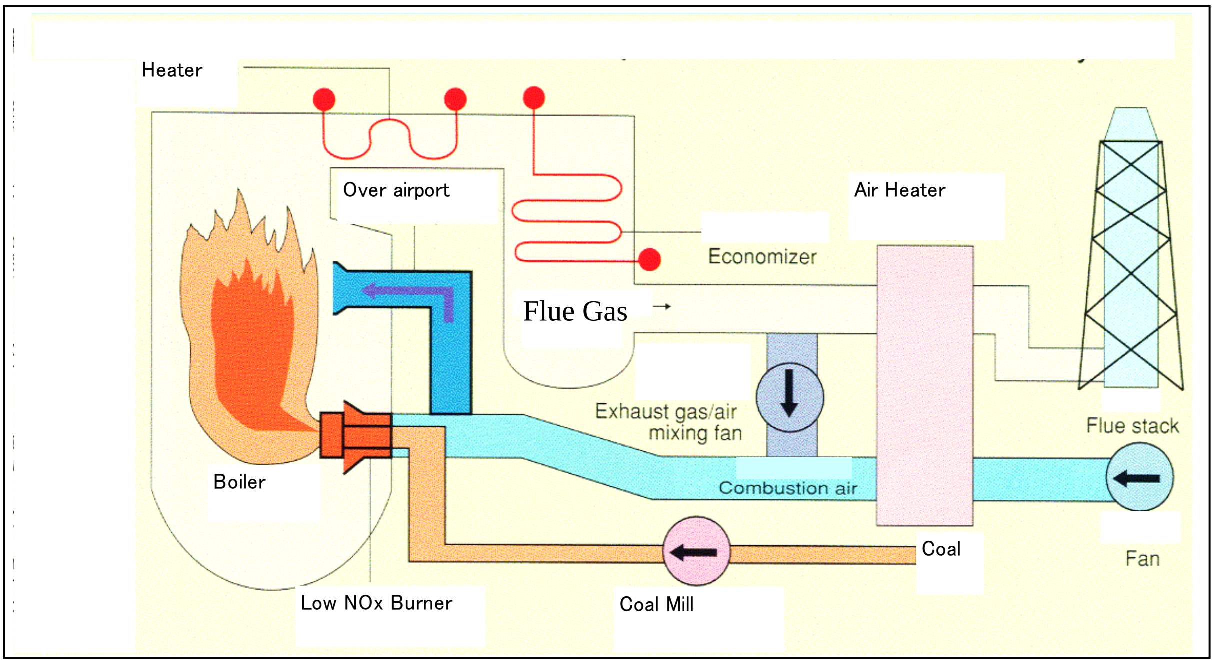


Figure 3.3.1-9 One of the combustion methods of Boiler

Source: JICA study team

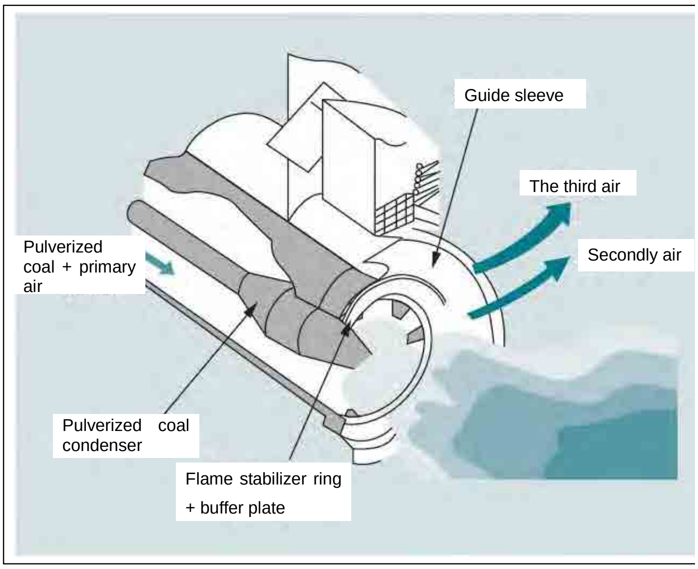


Figure 3.3.1-10 One of the types of Low NOx Burner

Source: JICA study team

3.3.2 Turbine

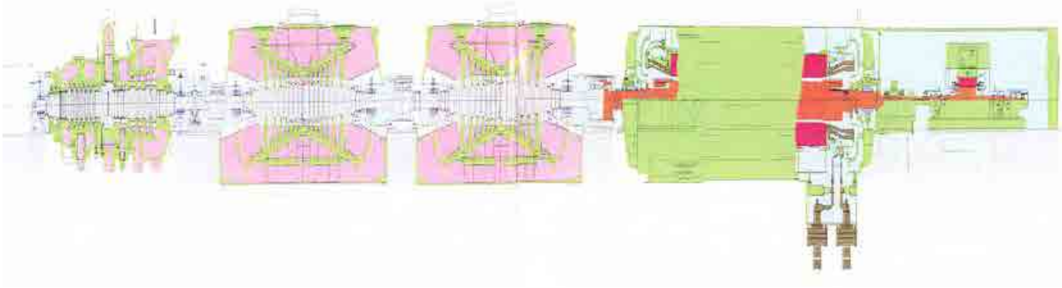
(1) Turbine Configuration

Type	Tandem compound, single reheat, condensing turbine
Rated output	1,000 MW
Rotating speed	3,000 rpm
Steam condition at turbine inlet	25 MPa/600°C/620°C
Turbine control system	Digital electro-hydraulic governor
Number of extraction	8 stage

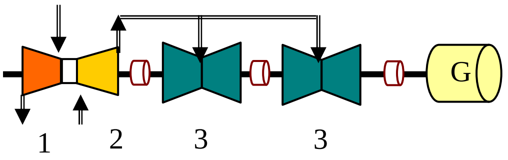
1) Turbine Type

Steam Turbine Type is classified into Tandem Compound and Cross Compound. Turbine arrangement composed of high pressure turbine (HP), medium pressure turbine (IP), (or Combined HP-IP turbine) and low pressure turbine (LP). Both turbine arrangements are shown in Figure 3.3.2-1.

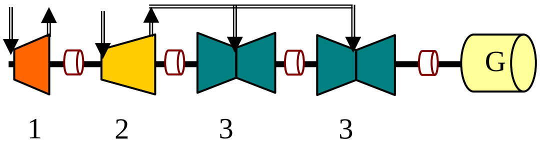
Tandem Compound Type



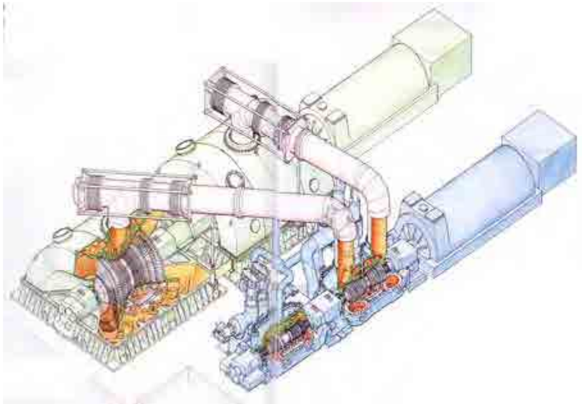
Type1

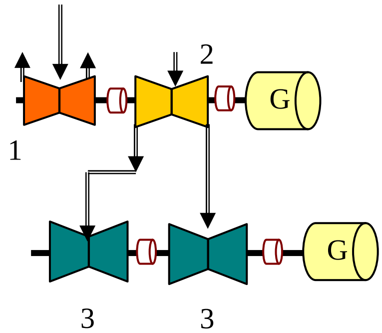


Type2



Cross Compound Type:





1: High pressure turbine 2: Intermediate pressure turbine 3: Low pressure turbine
G: Generator

Figure 3.3.2-1 Turbine Arrangements

Source: JICA study team

Tandem Compound is generally applied in the class of below 1,300 MW capacity power plant. There are some advantages to Tandem Compound in comparison with Cross Compound, which are turbine house space-saving, short maintenance period and low plant cost.

Cross compound is applied in the class of over 1,300 MW capacity power plants for the reason that this type is to simplify the turbine house layout, to minimize the length of LP turbine last blade and to reduce each Generator Capacity.

2) Number of Turbine Casing

Tandem Compound consists of two types of casing arrangement such as type 1 (three Casings) and type 2 (four Casings), which is shown in Figure 3.3.2-1. Manufactures tend to apply combined HP-IP turbine structure to their turbine so as to improve economics. In case of Type 2, maintenance period and plant cost is expected to increase compared to Type1 due to the one additional Casing. Therefore, Type 1 arrangement is selected from economical and maintenance reason for model power plant.

(2) Steam Turbine Plant Structure

1) General

The steam turbine consists of a multi cylinder; tandem compound, four exhausts, and condensing reheat type. The high pressure-intermediate pressure turbine is of HP-IP combined element, i.e., the high pressure turbine and intermediate pressure turbine are arranged in one cylinder. The regenerative condensing unit operates at 3,000 rpm and will be provided with eight uncontrolled extractions for regenerative feed water heating. The LP turbine will exhaust into condenser against condenser back pressure of 8.47 kPa. The rotors of the whole shaft line will be provided with integral expansion sleeve couplings and rigidly interconnected.

The unit would be capable of generating at MCR and also with Valves Wide Open (VWO) conditions continuously with maximum cooling water temperature of 33°C and 3% make-up to the heat cycle. It will also be capable of operating continuously under HP heaters out of service condition generating rated output. The design of the turbine would be based on the maximum pressure and temperature it is subjected to. A quick acting “HP and LP Turbine Bypass Station” would be provided;

- to stabilize boiler condition with sudden load dump/turbine trip out;
- to protect the turbine during pressure rise resulting from sudden load throw off; and
- for quick start-up of the unit following a hot trip out by proper matching of boiler steam and turbine metal temperature.

The steam turbine will be equipped with:

a) a hydraulic/motorized turning gear for uniform heating/cooling of the rotor during start-up/shutdown;

b) a digital electro-hydraulic governing system using high pressure control oil to ensure fast speed of operation and safety backed by conventional mechanical governing and safety system ensuring stable operation under grid fluctuation and load throw condition; and

c) a self-contained lubricating oil system for supplying oil to the turbine and generator bearings and also to the generator seal oil system.

2) HP Turbine

The HP turbine mainly consists of a bladed rotor, outer casing and bladed inner casing. The live steam will be led to the valve casing at both sides of the turbine, mounted vertically to the turbine casing. Within each of the valve casings, one stop valve and one control valve will be installed. After expansion in the HP blade, a part of steam will be extracted at a proper stage of the HP casing to the final HP feed water heater, and the other part of the steam reaches the exhaust chamber of the horizontally split outer casing. The exhaust steam will be led to the Reheater. The inner casing will be axially fixed in the plane of the steam inlet on the centerline. In addition, in the plane of the steam inlet and the exhaust plane, the inner casing will be supported via sliding pieces within the outer casing.

3) IP Turbine

IP turbine consists of rotor, outer casing and inner casing. The hot reheat steam will be led to both valve casings at the sides of the IP turbine bolted to the turbine casing. After expansion in the turbine blade, a part of the steam will be led to the relevant HP heater at a proper stage of the IP casing, and the other part of the steam reaches the exhaust area of the IP turbine. The outer casing will be split on the horizontal plane at the level of the turbine axis. The inner casing is also split horizontally at the level of the turbine axis.

4) LP Turbine

The double flow LP turbine consists of a casing and rotor with blade. The steam will be led from the IP exhaust via a cross over pipe into LP turbine. After expansion, for some parts of steam, the steam will be extracted at proper stages of the LP casing into relevant LP heaters and the other part of the steam will flow via the circular differs into the exhaust area of the LP turbine and then downwards into the condenser. The LP casing will be a welded construction and split horizontally on the level of the turbine axis. The water injection system in the casing of the LP turbine ensures cooling during no-load and low-load operation. The casing will also be equipped with a rupture disc to protect it against overpressure. To ensure quick passing through the critical speeds during turbine run-down, a vacuum breaker will be fitted to the generator side of the LP casing.

5) Heat Balance Diagram

Constitution of the steam water cycle is designed with the following conditions:

a) single reheat condensing system
b) eight-stage extractions for feedwater heating
c) installation of the steam turbine or motor driven boiler feed pump

Major parameters of the cycle at design condition are as follows:

i. main steam at inlet to turbine: 25MPa 600°C
ii. reheat steam temperature at inlet to IP turbine: 620°C

The detailed study about Turbine heat balance diagram will be conducted at Feasibility Study stage.

6) Comparison of steam turbine

Based on above descriptions, JICA study team made comparison table between tandem compound and Cross compound as follows:

Table 3.3.2-1 Comparison of Tandem Compound and Cross Compound type

Ev.	Cross Compound Type	Item	Tandem compound type	Ev.
○	Yes	Application to USC	Yes	○
○	Yes	Large capacity (i.e. 1,000 MW or above)	Yes	○
	Turbine size is wider than Tandem compound type. However, primary and secondary generators are necessary.	Turbine & generator length and width	Turbine total length is longer than cross compound type.	
	More expensive than Tandem compound type	Unit cost	Cheaper than cross compound type	○
	A width of Turbine building is bigger than tandem compound types of turbine building	A size of Turbine building	A length of turbine building is longer than cross compound type.	
	More expensive than Tandem compound type	Construction cost	Cheaper than cross compound type	○

Ev.: Evaluation ○: superior ：inferior

Source: JICA study team

7) Advanced technology of USC turbine

Then advanced technologies are adopted to USC power plant recently in improved turbine rotor material, adopted double pipe structure, rotor cooling and heat shield, over-lay welding for bearing part, rotor outside cooling and cooling by extraction steam.

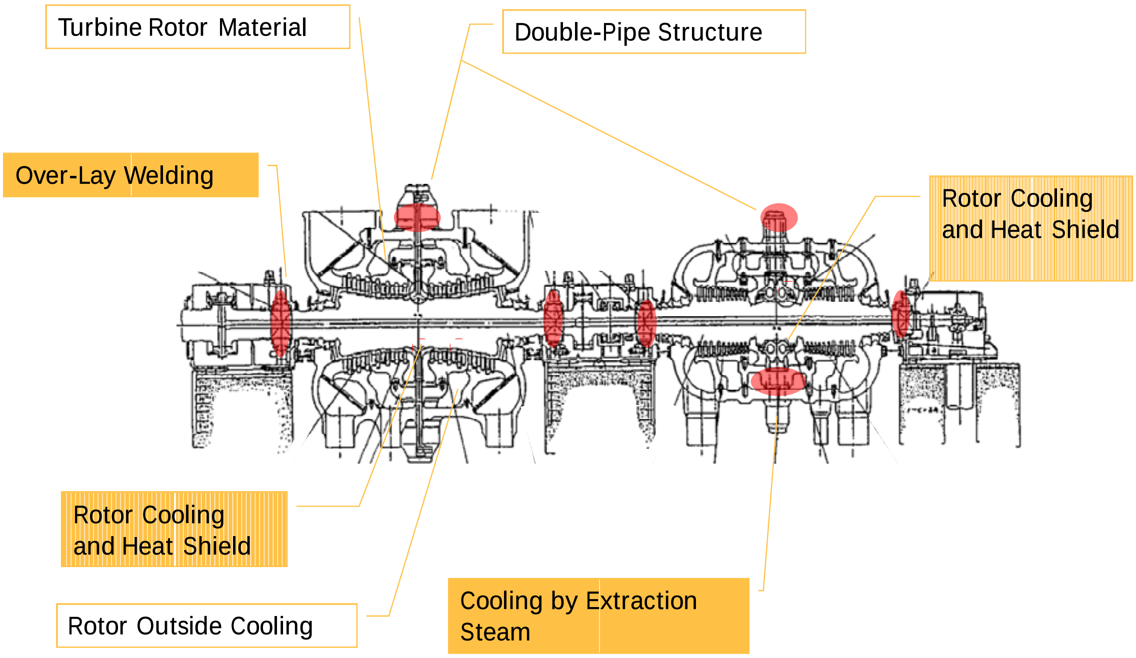


Figure 3.3.2-2 Advanced technology of USC turbine

Source: JICA study team

(3) Turbine auxiliaries

1) Condensate Polishing System

The condensate polishing system will be designed to remove dissolved and suspended solids, corrosion products and other impurities from condensate during start-up, normal operation and during the periods of condenser tube leakage to maintain the feedwater and steam purity requirements of the boiler and turbine. The condensate polisher will be located in condensate feedwater cycle between the condensate pump discharge and gland condenser.

The detailed study about Turbine Condensate Polishing System will be conducted at FS stage

3.3.3 Coal handling system

The coal handling system should include an unloading jetty, coal unloaders, coal receiving conveyers with trestles, coal storage yard, stackers/reclaimers, circulation conveyors (if required) and coal discharging conveyors to the power plant of coal storage bunkers for boiler.

A fuel coal used for Model Power Plant is Low Rank Coal and they will be transported from coal mines in Kalimantan and/or Sumatra to Model Power Plant site.

(1) Capacity of Coal Transportation Barge

The sea near the Model Power Plant has a relatively shallow berthing condition so a large coal vessel, such as Panamax size or etc, cannot access the site. Considering sea geographical conditions at the Model Power Plant site, small capacity coal transportation barge (8,000 to 13,000 DWT barges are available in Indonesia) will be used. In this Pre FS, 13,000 DWT barge is used for basic calculations.

1) 13,000 DWT barge requires approx. 6.0 meter sea depth. Length of Trestle, from seashore on the Model Power Plant to unloading jetty, will be approximately 3.0 to 4.0km. This means that suitable construction cost will be needed for the long Trestle and unloading jetty

- Coal Barge : 13,000 DWT,
  Typical Size: W=28 m × L=114 m × D= 5.5m
  (For 8,200 DWT barge, W=27.4m × L=91.5m × D=5.5m
- Number of Coal Jetty : 2 berths for 1 Unit, 4 berths for 2 Units
- Size of Berth : W=25 m × L=750 m (with Unit-2)
- Length of trestles : Approx. 3.0 to 4.0 km (Assumption)
- Sea Depth HWL : 7.5m
  LWL : 6m

2) Allocation Plan of Coal Transportation Barge

The required number of 13,000 DWT barges for coal transportation for Model Power Plant 1,000 MW x Unit-2 (Unit-1in the future) will be 580 barges. Calculation is as follows;

For Unit-1

3,767,000 t/y (Coal annual consumption) /13,000 DWT/barge = 290 barges/y

For Unit-1 & 2 (Future)

7,534,000 t/y (Coal annual consumption) /13,000 DWT/barge=580 barges/y

(2) Coal unloading & Coal storage

1) Coal storage capacity is 30 days for Unit1 as the base load operation.

Coal consumption (ton) = 12,400 (t/day) × 30 (days)

∴ Coal storage capacity = 314,000 ton

However, PLN required 30days + about 1 week for roof type of coal storage yard.

∴ Coal storage capacity for 36 days = 372,000 ton

Including 5% margin = 391,000 ton

2) Coal unloader capacity (2 sets for 1 Barth): 2 sets/ Berth x 2 Berths for 1 unit

Means = 4 sets for 1000MWx 1 unit

Non-loading days: Annual Inspection days: 55 days

Average of Troubles days: 7 days

Foul Weather: 15 days

Total: 77 days

∴ 365days-77days= 288days/year

Loss of parking and leave for barge: 4 hours

Unloading efficiency: 65% for grub and bucket, 70% for continuous type

Possibility of unloading duration times: 20hour

Berth occupancy ratio: Less than 55%

Based on above: Max.700 ton/hr/set

Numbers of unloader: 4 sets (2 sets × 2 Barth)

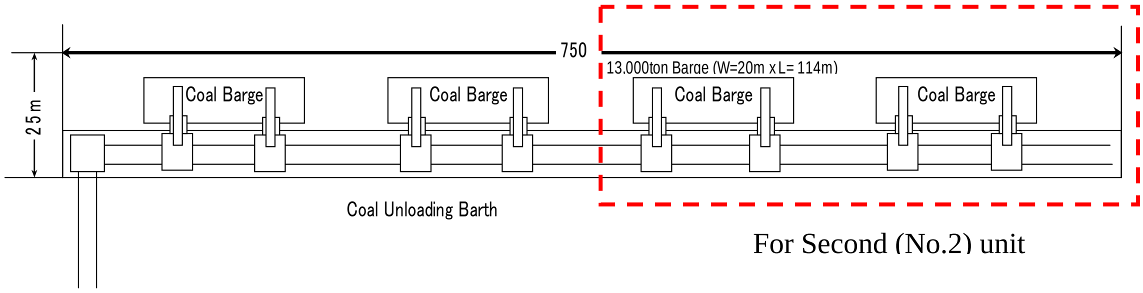


Figure 3.3.3-1 Coal Unloading Jetty Plan

Source: JICA study team

3) Coal receiving conveyer capacity (for 1 unit)

Unloader: 700 ton/hour × 4 sets for 1 unit

Numbers of Conveyer Lanes: 2 Lanes for 1 unit

Conveyor capacity: Max 2,800t/hr/set × 1.2 (margin)

∴Conveyer capacity = 3,360 ton/hr/set

Number of conveyor for 1 unit: 3,400 ton/hr × 2 sets

Total Number of conveyor = 4 sets for 2 units

4) Coal storage yard

There are five types of coal storage yards, and JICA study team applies outdoor stock pile type with coal dust nonproliferation sprinkler (for protection of fire) to Model Power Plant, since it is very reasonable for the construction cost.

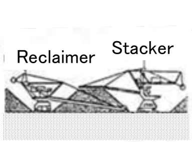
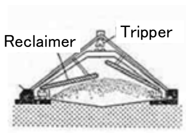
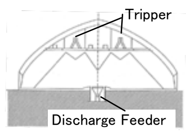
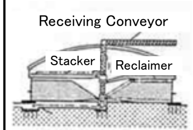
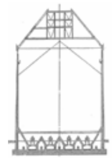
	Outdoor type	Indoor type			
	Stock Pile	Gabled roof A	Gabled roof B	Dome	Silo
Coal Storage Conceptual Diagram					
Multiple Storage by Coal Brands	Enable	Enable		Difficult	Disable (Multiple silo system enable the multiple storage by Coal Brands.)
Track Record	Many	Many (Especially in Europe)		Not many	Increase late years
Measures against Explosion-proof	Not necessary	Dust collector/ Ventilation system/ Water spray/ Explosion-proof apparatus			
Measures against Coal Dust Dispersion	Water spray/ Wind-resistant Fence	Not necessary			
Ventilation system	Not necessary	Required			
Rainwater treatment system	Required	Not necessary			
Area	Base(100%)	100%		70%	35%

Figure 3.3.3-2 Comparison table of coal storage yard

Source: JICA Study Team

Out door type

Gabled roof type(Indoor type)

Doom type (Indoor type)

Silo type

Source: JICA study team

Photo 3.3.3-1 Typical type of coal storage

5) Coal storage capacity

PLN requirement of the coal storage yard capacity is 30days outdoor type + around 1 week (6days) for indoor or roofing type of coal storage yard.

Total coal storage capacity: around 391,000 ton

Coal storage yard capacity= 310,000 ton (for 30days) + 62,000 ton (for 6days)× 5% (Margin for the storage) ≅ 391,000 ton

Apparent specific gravity of coal: 0.8 ton/m^3

Storage efficiency: 0.77

Pile capacity = (14 m + 50 m) × 13 m × 1/2 × L 390 m x 0.8 × 0.77 ≅ 100,000 t

100,000t × 4 piles = 400,000 t >391,000 t

Therefore, coal storage yard capacity is 400,000t (500,000m^3)

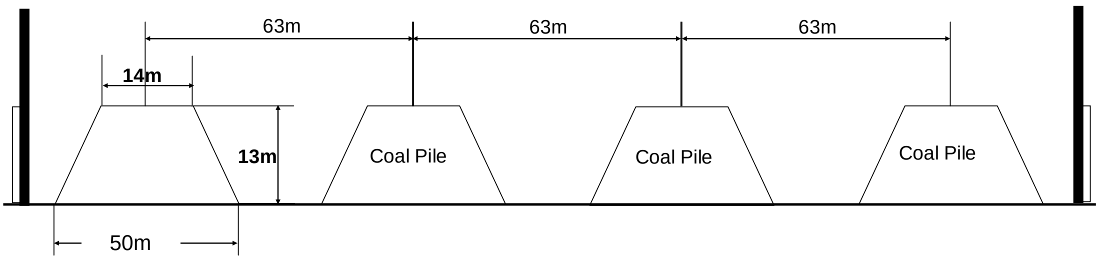


Figure 3.3.3-3 Coal Storage Yard Plan

Source: JICA Study Team

6) Stacker and Reclaimer

Stacker: 1,500 ton/hr × 4 units & Reclaimer: 750 ton/hr × 4 units for model power plant.

The detailed study about Stacker and Reclaimer will be conducted at FS stage

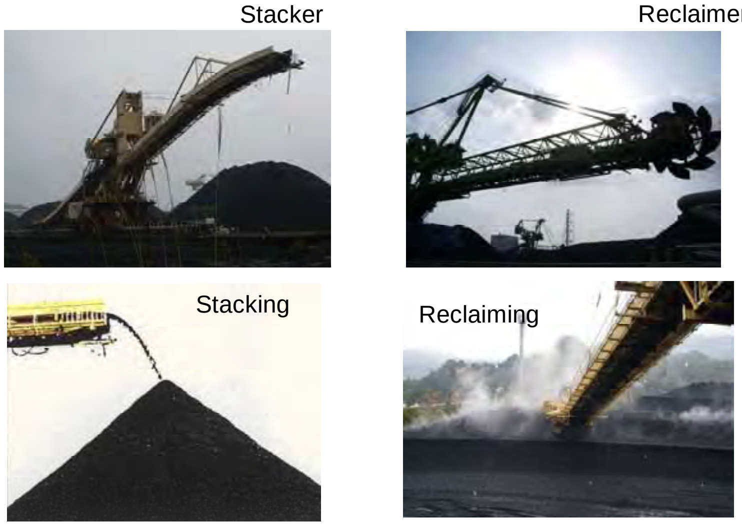


Photo 3.3.3-2 Stacker and Reclaimer

Source: JICA study team

3.3.4 Circulating water Intake.

The water source used for cooling the condenser and for some other requirements (Sea water FGD, cooling and auxiliary equipment) shall be taken from sea (salt water).

(1) Circulating water intake volume (Assumption for estimation)

The estimation of circulating water intake volume for 1000MW Model Power Plant is as follows;

CW intake water temperature (for design) : 30ºC

CW discharge water temperature : 30ºC + 9ºC (intake and discharge differential 7ºC + see water FGD temperature increase 2ºC)

Requirement circulating water : 150 m^3/MWh

Requirements sea water for auxiliaries : 3.5 m^3/sec (Assumption)

Circulating water intake volume (m^3/sec) = 150 m^3/MWh x 1000MW + 3.5 m^3/sec

∴ Circulating water intake volume = 45.5 m^3/sec

Circulating water pipe

Circulating water intake pipeline to the pump station from the water intake tower

45.5 m^3/sec =2.5m/sec (intake velocity) × ($\pi D^2/4$)

∴ Circulating water pipe = ϕ 4.8m

Circulating water supply pipeline to the condenser from the pump station;.

45.5 m^3/sec =3m/sec (supply velocity) × ($\pi D^2/4$)

Circulating water pipe = ϕ 4.4m

(2) Circulating water intake System

Circulating water intake with Electrical hydro-chlorination system should consider sea geographical conditions. Model Power Plant site has relatively shallow berthing condition, therefore the plan of water intake system are Plan-A and Plan-B.

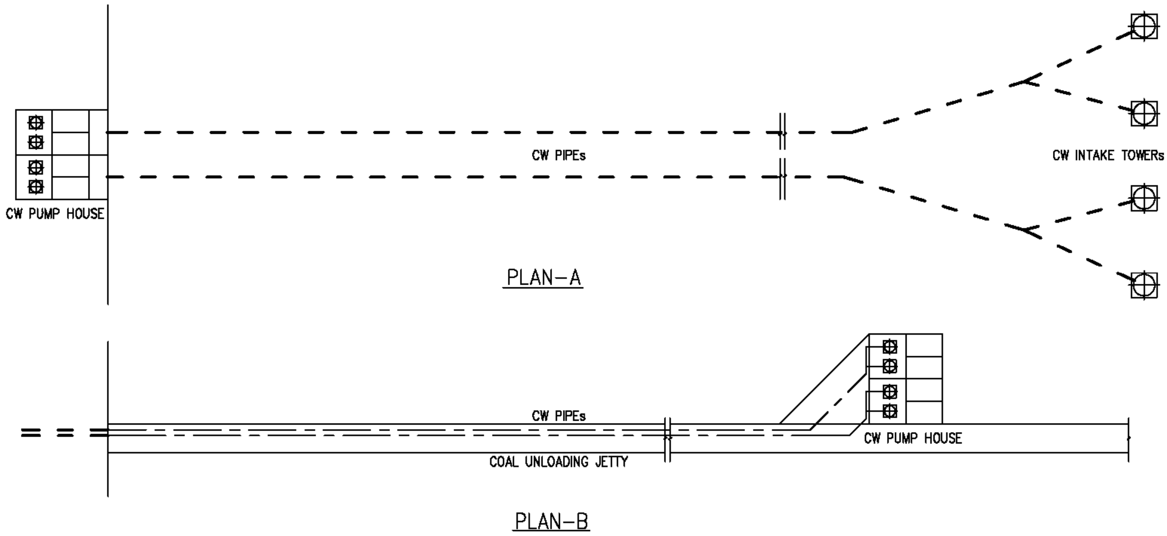


Figure 3.3.4-1 Typical type of CW Intake

Source: JICA study team

Circulating water intake system will be finalized after inspection of seabed depth at the feasibility study stage.

3.3.5 Supplemental Fuel Oil Supply System

The supplement fuel oil system will be applied for ignition and warm-up purposes of main boiler, fuel oil for auxiliary boiler and used for fire fighting water pump (diesel driven type).

(1) Supplemental fuel oil system

Supplemental fuel oil system should be considered as follows.

Type of fuel oil	: Light oil (HSD)
Fuel oil unloading system	: Fuel oil unloading pumps, strainers and flow mater
Fuel oil storage tanks	: 1750 kl × 2 tanks
Fuel oil supply system	: Transfer and supply pumps

(2) Supplemental oil consumption and storage capacity (Rough estimate);

Rating output	: 1,000 MW
Plant thermal efficiency	: 40% (at Rating output)
Fuel oil calorific value	: 10,800 kcal/kg (Specific gravity is 0.86)
Max. Operation	: 120 hours (for 5days) at 30% Rating output (ignition and warm-up)
Number of fuel oil tank	: 2 tanks

Fuel oil consumption =1,000,000 kW × 860 kcal/kg / 0.4 × 10^6 × 0.3 / 10,800 kcal/kg × 10^6

=59,722 kg/hr

=59,722 kg/hr × 0.86 / 1,000 = 51.4 kl/h

∴ Oil consumption = 51.4 kl/h

Oil tank storage capacity = 51.4 kl/h × 120 h × 1.1 (Margin) / 2 tanks= 3,400 kl

∴ Oil tank storage capacity = 3,500 kl/tank > 3,400 kl/tank

3.3.6 Ash Handling System

Ash can be categorized be into two types as follows;

- Bottom ash from the bottom hopper of boiler.
  (About 10 - 20% of the total amount of coal ash)
- Fly ash from the hopper of economizer, air heaters and the electrostatics precipitators (About 80 – 90% of the total amount coal ash)

Ash is extracted from the various parts of coal-fired boiler as shown in Figure 3.3.6-1. Bottom ash is transported from bottom ash hopper of boiler to ash disposal area by conveyor transportation system and fly ash is from fly ash hopper of economizer, air heater and electrostatics precipitator can be transferred to fly ash silo by compressed air handling system or vacuum handling system.

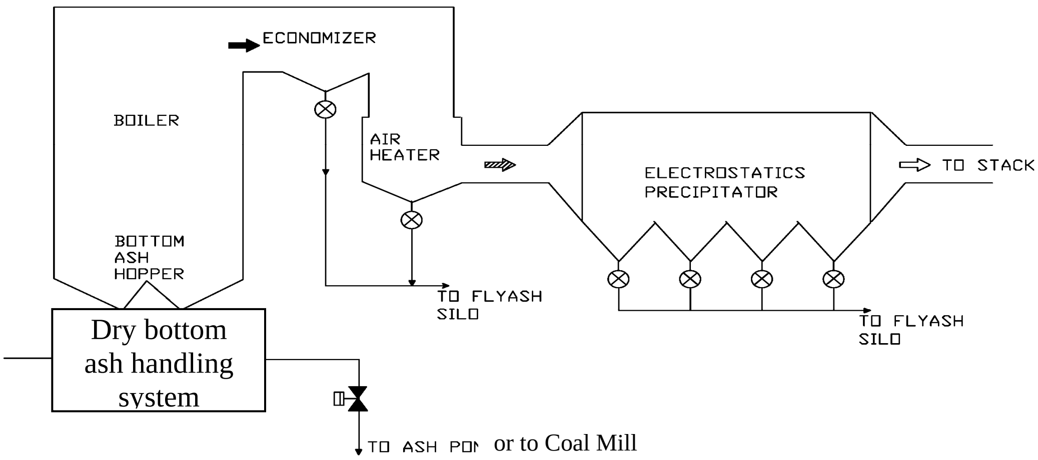


Figure 3.3.6-1 Illustration of ash extraction

Source; JICA study team

(1) Ash Collection and Disposal System

1) The ash handling system to be implemented for Model Power Plant will be designed to evacuate and dispose the fly ash as well as boiler bottom ash in environmentally friendly manner. A dry extraction and re-cycle system is considered for bottom ash and a completely dry extraction and dry disposal system is considered for the fly ash for the station. The ash handling system would be designed on the following basis:

a)	Coal consumption rate for 1,000 MW unit	538 t/h
b)	Total ash generated (6.2% of coal consumption)	34 t/h
c)	Ash quantities	
	a. Bottom ash (20% max)	7 t/h
	b. Fly ash (80%+10%)	31 t/h
d)	a. Bottom ash generation per shift of 8 hours	56 t
	b. Fly ash generation per shift of 8 hours	250 t

2) Boiler bottom ash handling system: Out of the two types of bottom ash removal systems that exist, the dry ash system and wet ash system, both systems are proven technology at present, however the investment cost of the dry system is a slightly higher than the wet system apart from other related problematic aspects to the boiler. Thus the proven dry ash collection and disposal system is proposed. Ash from Boiler bottom will be collected in the impounded hopper located below and would be slowly quenched. The bottom ash will be transported by a conveyor outside of the boiler from where it will be transported to coal again and combusted through a coal mill.

Fly ash system: Fly ash collected in air-heater hoppers, electrostatic precipitator hoppers and will be evacuated intermittently in an auto sequence mode using pneumatic vacuum system to ash Silo.

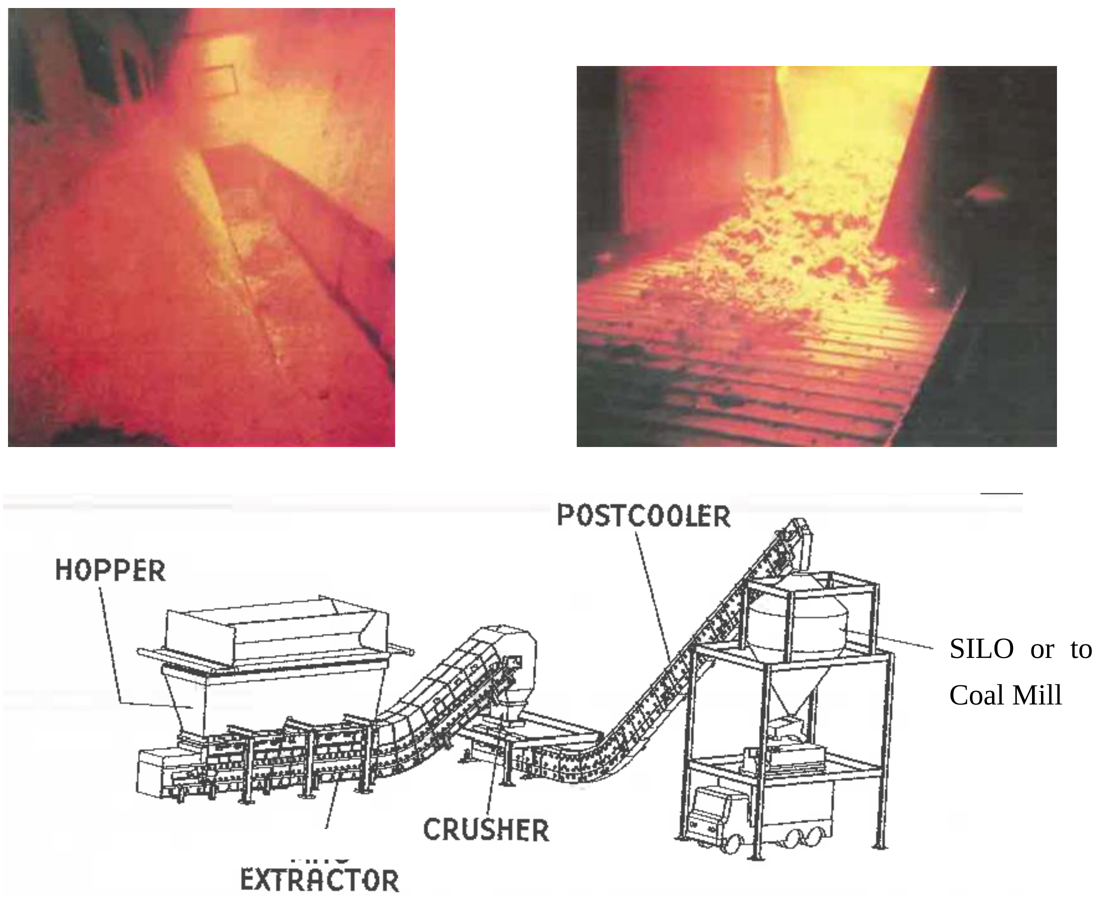


Figure 3.3.6-2 Dry bottom ash handling system

Source: JICA study team

3.3.7 Ash disposal area

1) Capacity of Ash Disposal Area

Nominal capacity of the ash disposal area is calculated based on the total volume of ash to be accumulated for the duration of a five-year operation and ash disposal volume are shown below.

Coal consumption should be referred to the Table 3.1-1 "Design Requirements of Model Power Plant".

Annual coal consumption : 3,767,000 (t/y)
Maximum monthly coal consumption : 368,600 (t/month)
Ash content of the Design coal is 5%.
Carbon content of the Design coal is 40.92%.

A. Volume of coal ash (per year) = 3,767,000 (t/y) x 5%
∴ 188,400 (t/y)

Unburned carbon in ash is 3% of the carbon content and its carbon content is 40.92% × 3% = 1.2%.

B. Volume of unburned carbon (per year) = 3,767,000 (t/y) × 1.2%
∴ 45,204 (t/y)
C. Annual total Ash and unburned carbon = 188,400 (t/y) + 45,204 (t/y)
∴ 233,604 (t/y)

D. Quantity of Ash for a five-year operation = 233,604 (t/y) × 5 (y)
∴ 1,168,000 ton for five years

2) Utilization of Ash

There are cement companies in Indonesia and these are using fly ash for cement admixture, and fertilizer factory as well. In case fly ash is sold to the cement company or fertilizer factory, the total ash disposal volume will be decreased and the lifetime of ash disposal area will be longer.

3) Ash disposal area (Rough estimate)

Quantity of disposed ash for a five-year operation: 1,168,000 ton
Specific gravity of disposed ash: 1.0 m^3/t
Depth of ash disposal area: GL-12.0 m (Top of Disposal Ash GL-0.5 m)
Ash disposal area = 1,168,000 ton × 1.0m^3/ton =1,168,000 m^3
In case of 2 units =1,168,000 m^3 × 2 = 2,336,000m^3
∴ (W1: 556 m + W2: 334 m) /2 × L: 500m × D: 11.5 m = 2,558,750 m^2 > 2,336,000 m^3

3.3.8 Environmental Protection Facilities

In order to meet the environmental regulation and requirement in Indonesia, following environmental protection facilities including a flue gas measuring system will be adopted at Model Power Plant.

(1) Dust Collection system

In order to remove abundance of soot and dust generated after coal burning, dust collectors are used, such as wet scrubbers as well as mechanical precipitator and electrostatic precipitator (ESP). The ESP is used practically because of the higher dust collection efficiency. It passes fuel gas between high-voltage electrodes (for discharge and dust collection) to let negatively-charged soot and dust adhere to the positive dust collection electrode and to periodically drop the accumulated matter to the bottom of the electrode by hammering. This process can remove more than 99% of soot and dust at the boiler outlet. Figure 3.3.8-1 shows that structure of a typical ESP.

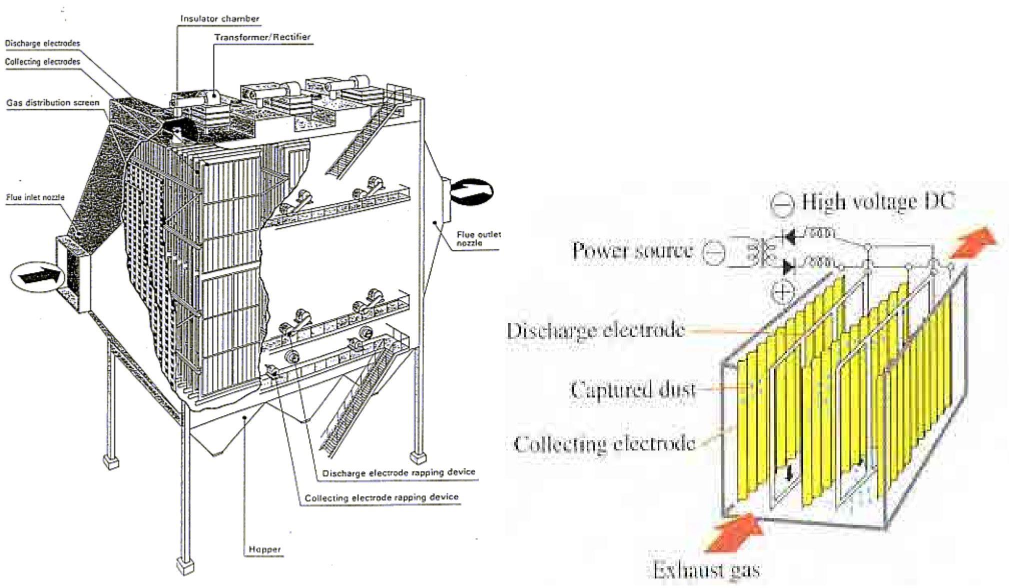


Figure 3.3.8-1 Structure of a Typical Electrostatic Precipitator

Source: JICA study team

In Model Power Plant, an installation of electrostatic precipitator is planned. To limit the dust concentration at the outlet to the stack to a value of 100 mg/m^{3}N, four sets of ESP, each having two parallel paths [with isolation provision for maintenance] will be provided. The ESP will have collection efficiency of around 99.8%. Dampers with more than 99.5% gas tightness will be provided to permit on-line maintenance of ESP fields. The ESP hoppers will have at least eight hours ash storage capacity. Table 3.3.8-1 shows that conceptual design data of ESP used by Model Power Plant.

Table 3.3.8-1 Basic Specification of ESP

Contents		Description
Design conditions		Pulverized coal fired boiler
Gas volume	m^3N/h	3,158,000 (Assumed)
Type		Low temperature electrostatic type (4-line)/unit
Input dust	g/m^3N	10.0 (Assumed)
Output dust	mg/m^3N	<100
Efficiency	%	99.0

Source: JICA study team

(2) Reducing NOx by Combustion Improvement

Generated when coal is burnt, NOx consists of fuel and thermal NOx. The former (normally 20 to 40% of nitrogen) is yielded by nitrogen changing during combustion, while the latter is generated by N_2 contained in combustion air reacting with oxygen at high temperatures. NOx generated by coal is much higher than liquid fuels and gas fuels. Accordingly, it is necessary to exam how to control and reduce NOx by taking the specific characteristic of coal

Thus, typical way for reduction of NOx is by a combustion improvement of the boiler, and the adoption of low-NOx burners and the combination of two-stage combustion is popular for use. Figure 3.3.8-2 shows that examples of NOx reduction based on the combustion improvement and Figure 3.3.8-3 shows that example of low-NOx burner structure respectively. In Model Power Plant, Low NOx burners and two-stage combustion should be provided.

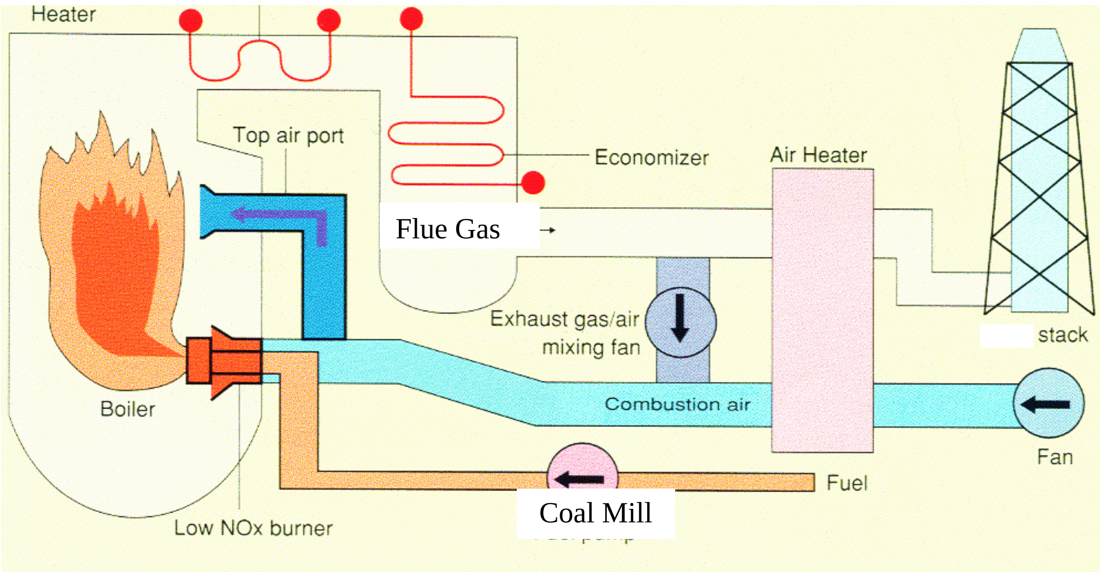


Figure 3.3.8-2 Examples of NOx reduction based on the Combustion Improvement

Source: JICA study team

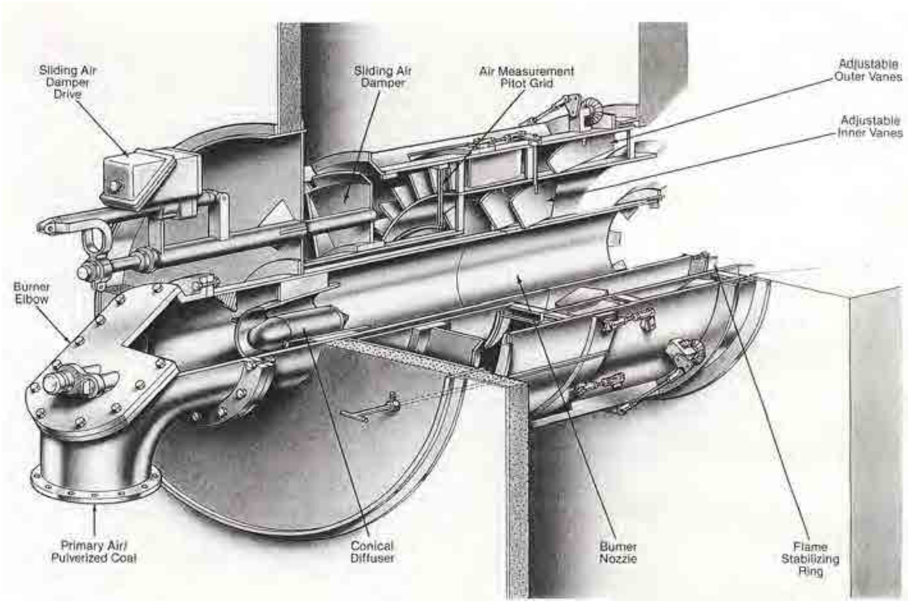


Figure 3.3.8-3 Examples of Low-NOx Burner Structure

Source; JICA study team

(3) Fuel Gas De-sulfurization Facilities

In general, the process of FGD system is roughly classified into three types: wet, semi-dry and dry. In Japan, the wet limestone-gypsum-process is most popular.

However, for Model Power Plant, Seawater Flue Gas Desulfurization (Seawater FGD) System should be applied to remove SO_2 from the flue gas stream. Figure 3.3.8-4 shows process of Seawater FGD system, the flue gas passes through the absorber where most SO_2 will be removed by interaction with seawater sent from the condenser outlet to the absorber. Then clean flue gas will leave the seawater absorber and discharge into the stack. Meanwhile, the discharge sea water from absorber will be routed into an aeration basin where air will be blown into the seawater as part of the aeration treatment process to oxidize and recover the sea water before discharge. After the oxidation, the recovered seawater will be discharged.

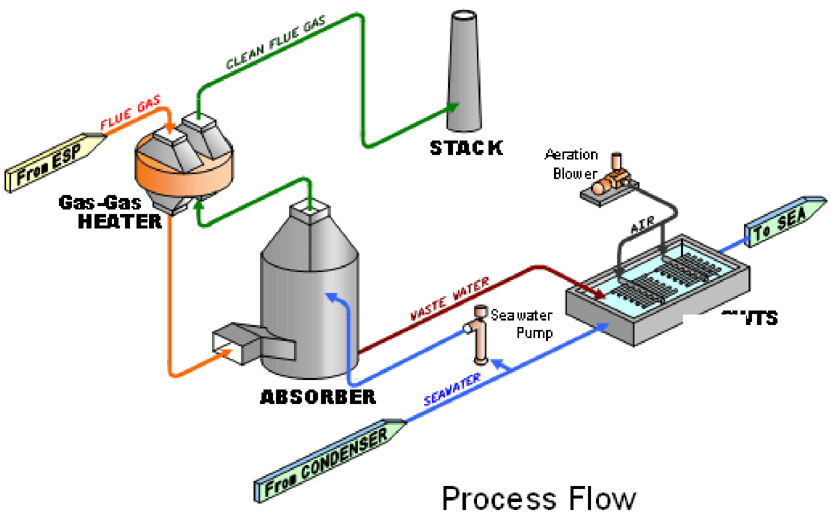


Figure 3.3.8-4 Sea water FGD system

Source: TSK Home Page: http://www.tsk-g.co.jp/en/tech/industry/seawater.html

For reference, Table 3.2.8-2 shows that a lists of fuel gas desulfurization processes being put to practical use.

Table 3.3.8-2 Lists of De-sulfurization Processes

	De-sulfurization process	Absorbent	By production
Wet type	limestone slurry absorbing method	Limestone, hydroxide calcium oxide, dromaite	Sludge of a gypsum (recovery) sulfur acid hydroxide calcium subject (abandonment)
	hydroxide magnesium oxide slurry absorbing method	Hydroxide magnesium	SO_2, Gypsum (recovery), magnesium sulfur (abandonment)
	alkali solution absorbing method	Sodium hydroxide, sulfur acid sodium, ammonia solution, etc.	Sulfur acid sodium, sulfur/sulfuric acid, ammonium sulfate (recovery)
	double alkali method	Sodium carbonate, ammonia, sulfur acid aluminum	Gypsum (recovery)
	oxidization absorbing method	Catalyst addition rare sulfur acid	Gypsum (recovery)
	Seawater absorbing method	Seawater	-
Semi-dry type	spray drier method	water calcium oxide, sodium bicarbonate, sodium carbonate, hot water (coal ash use)	Sulfur acid calcium, gypsum (abandonment or reclamation)
	desulfurization + water spray method in a furnace	Limestone	Sulfur acid calcium, gypsum (abandonment)
Dry type	inside of furnace, and the gas duct, lime blowing-in method	Hydroxide calcium, steam (coal ashes use)	Sulfur acid calcium, gypsum (abandonment or reclamation)
	activated carbon adsorbing method	Activated carbon (activity coke)	Sulfur acid (sulfur, liquid SO_2) (recovery)
	The electronic irradiation method	Ammonia	Sulfate of ammonia

Source: JICA study team

(4) Waste Water Treatment system

The waste water generated from the proposed 1,000 MW Model Power Plant would be treated for its maximum possible reuse in the power plant area. The unutilized waste water collected from various sources, after treatment, will be led to a Central Monitoring Basin. The final discharge from the waste water treatment plant should meet the Indonesian Environmental Standard, and the discharge will pass through an open channel or pipe.

3.4 General Arrangement of 1,000 MW Coal Fired Power Plant

Refer to Figure 3.4-1 General Arrangement of 1,000 MW Coal Fired Power Plant

3.4.1 Condition of Plant Site

- Total plant area : 1,759,593 m^2 (176ha)
- Plant site level : GL = MWL+2.8m *after reclamation
- Sea bed level : 3 km from site boundary MWL-5.4m
  3.5 km from site boundary MWL-6.4m
- Original condition of the site: 40% of site is natural ground area
  60% of site is fish pond and mangrove area
  Refer to 2.1.1 Condition of Preset Site Area

3.4.2 Required Area of the Each Facilities and Parts

(1) The areas for the other purpose

a) Coal Blend Center : Min. 13.5ha required by PLN

250 m × 572 m= 143,000 m^2 (14.3 ha) *included 10% margin

b) Photovoltaic Assemble Factory Area: 2.0ha required by PLN

100 m × 200m= 20,000 m^2 (2.0ha)

c) Natural mangrove and green zone (Environmental Regulation)

: 100 m from shore line, 100 m × 1,130 m= 113,000 m^2

d) Sub Total=276,000 m^2 (27.6ha)

(2) The area for the Power Plant

Power Plant Area : 1,000 MW × 2 Units (1000MW x 1 Unit future)
450 m × 947 m= 426,150 m^2

500 kV Switchyard : 500kV bauble Bus with 1+1/2 Circuit Breaker (1.5CB) configuration
165 m × 194 m= 32,010 m^2

Coal Storage Area : Open Type Storage Yard
Unit-1 566m x 336m= 190,176 m^2
Unit-2 566m x 252m= 142,632 m^2

Total 566 m × 588 m= 332,808 m^2

Ash Disposal Area : five-year storage for 2 Units
(Wa: 590 m + Wb: 360 m) /2 × L: 634 m= 301,150 m^2

Sub Total= 1,092,118m^2 (109.2ha)

(3) Others (Temporary office and storage, Ware House, Green area and etc,.)

1,759,593 m^2 - 276,000 m^2 - 1,092,118 m^2 = 391,475 m^2

Other Are 391,47 5m^2 (39.1ha)

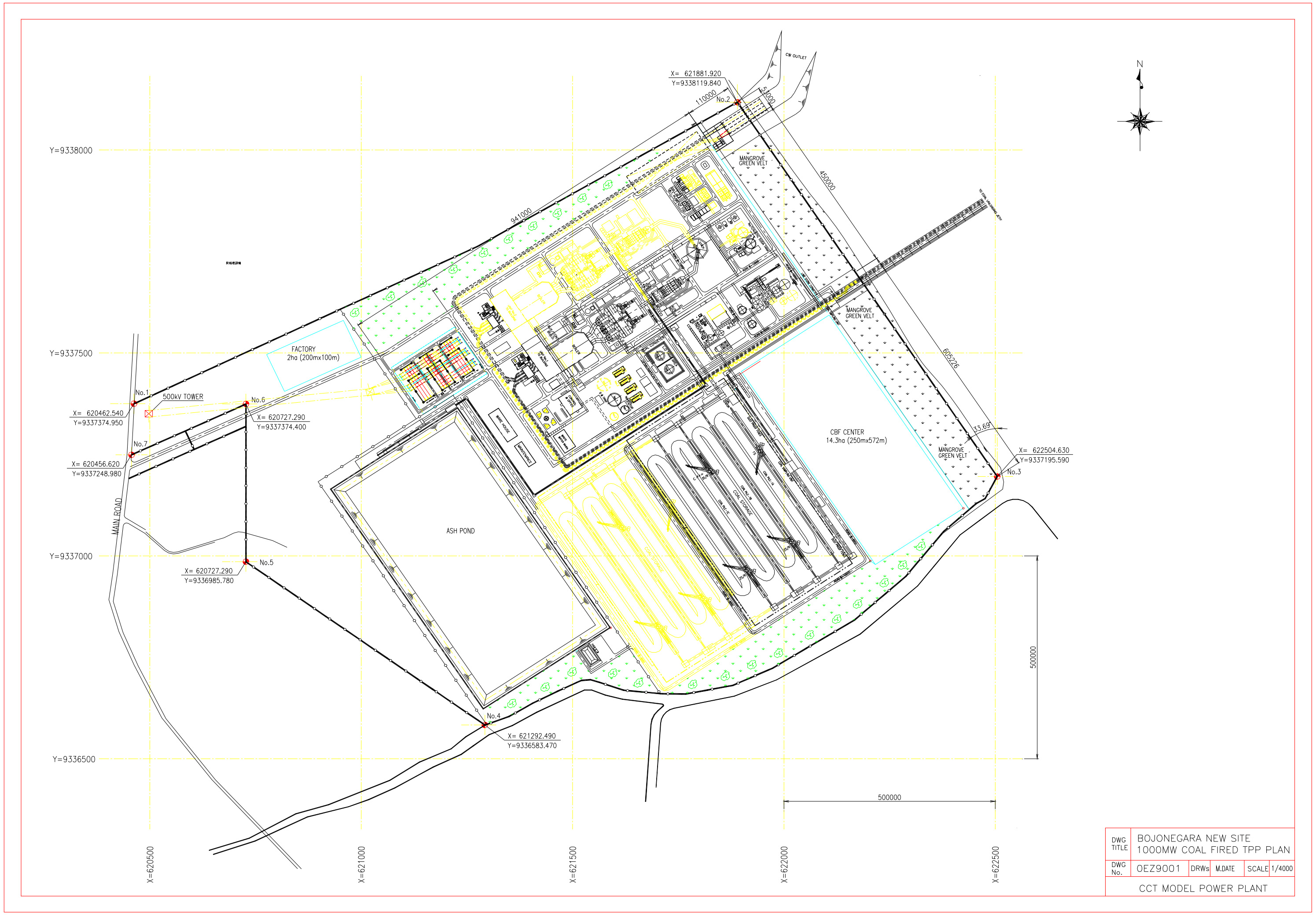


Figure 3.4-1 General Arrangement of 1,000 MW Coal Fired Power Plant

Source: JICA study team

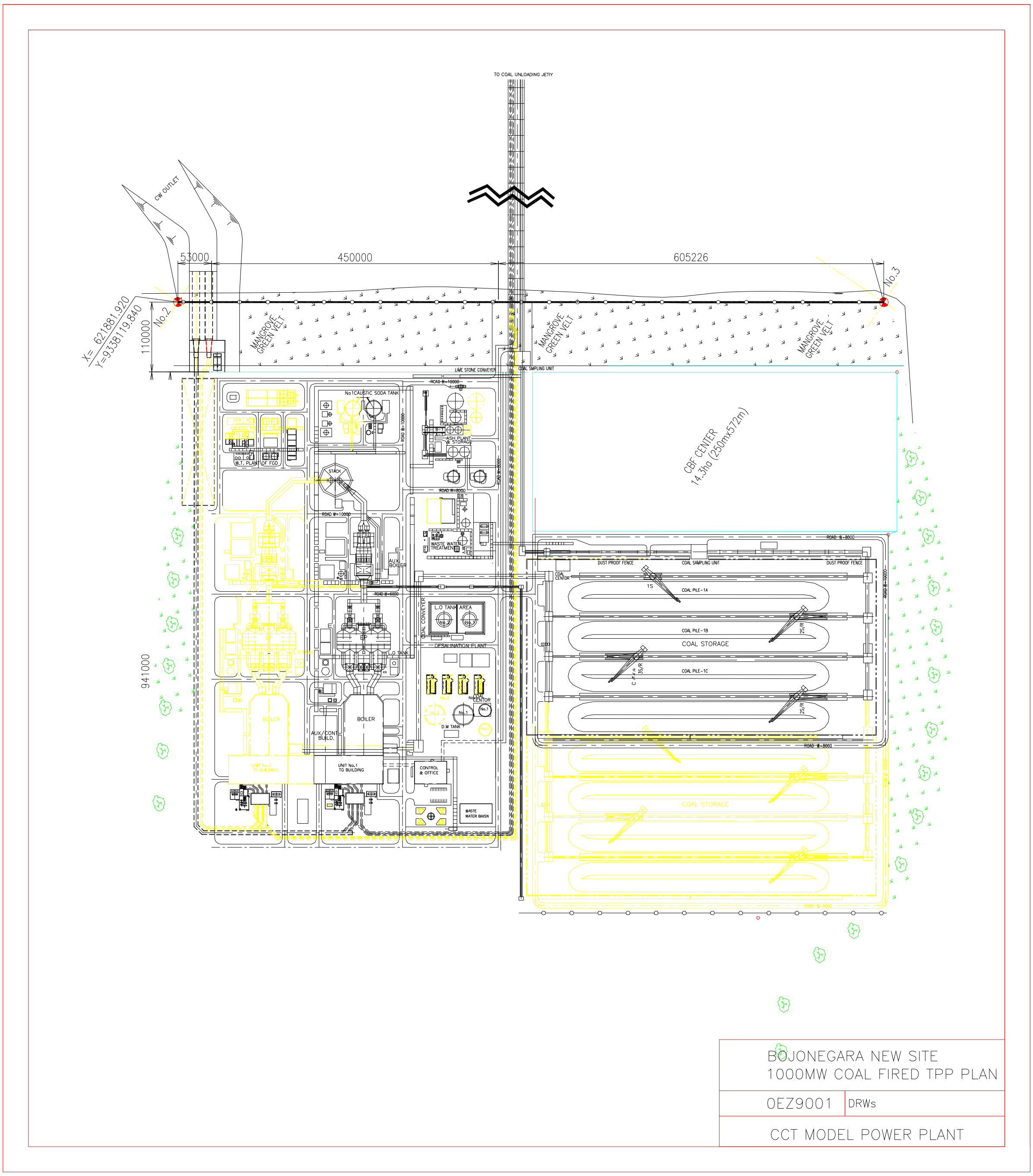


Figure 3.4-2 General Layout of 1,000 MW Coal Fired Power Plant

Source: JICA study team

3.5 HV Switchgear and transmission system

500 kV switchgear has the function to transmit power from Model Power Plant to the PLN national power grid at voltage of 500 kV power line. 500 kV switchgear is arranged at outdoor switchyard within Model Power Plant boundary fence, and 500 kV busbar system is double bus with 1+1/2 circuit breaker (1.5CB) configuration.

500 kV switchgear station is designed to be three diameters (bays) and is able to connect to 10 circuits: two circuits for Unit-1 generator transformer with auxiliary transformer of 1,000MW power plant, two circuits for Unit-1 generator transformer with auxiliary transformer in the future, two circuits for PLN national power grid, two circuits for PLN national power grid, in the future and two circuits for start-up transformer.

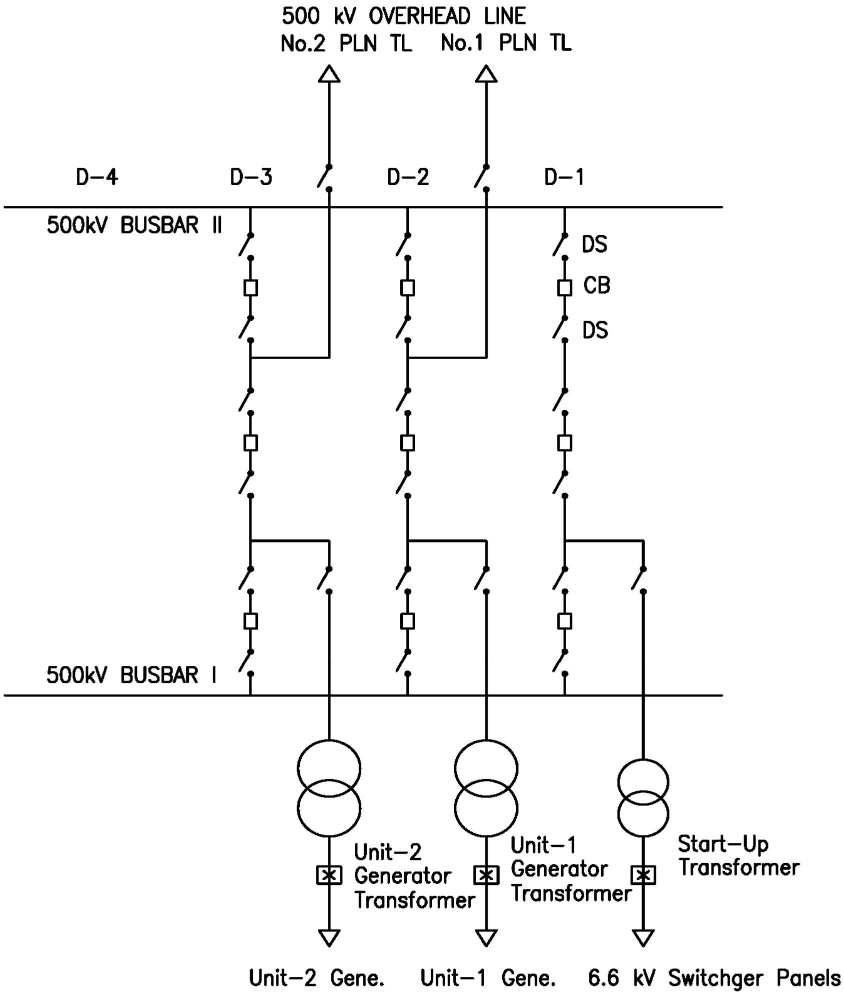


Figure 3.5-1 Single Line Diagram of 500 kV Switchyard

Source: JICA study team

Equipment of 500 kV switchyard as follows;

No.	Items	Unit	Q'ty	Remarks
A	500kV Switchyard Equipment			
1.1	Circuit Breaker (3-phase)	sets	8	
1.2	Disconnecting Switch Bus Pantograph (3-phase)	sets	11	
1.3	Disconnecting Switch (3-phase)	sets	22	
1.4	Disconnecting Switch Ground (3-phase)	sets	5	
1.5	Lightening arrester (3-phase)	sets	3	
1.6	Current Transformer Line (3-phase)	sets	2	
1.7	Current Transformer Diameter (3-phase)	sets	4	
1.8	Voltage Transformer for Instrument (3-phase)	sets	2	
1.9	Voltage Transformer for Line Protection (3-phase)	sets	2	
1.10	Line Trap (3-phase)	sets	2	
1.11	Connection Post Insulator, etc,.	sets	2	
1.12	Marshaling Kiosk	sets	3	
2	Switchyard Structure	set	1	
3	Cabling	set	1	
4	Busbar, Conductor Clamp act	set	1	
5	Earthling System, Copper Strip	set	1	
B	Control and Protection for 500kV Switchyard			
1.1	Control Panel	sets	2	
1.2	Circuit Panel	sets	2	
1.3	Distance Protection	sets	2	
1.4	Circuit Breaker Panel	sets	2	
1.5	Busbar Protection *1	set	1	
1.6	Regulation Panel *1	set	1	
1.7	Synchronizing *1	set	1	
1.8	Energy Meter*1	set	1	
1.9	Interface Cubicle Scada *1	set	1	
1.10	Fault Recorder Panel *1	set	1	
1.11	Event Recorder Panel *1	set	1	
1.12	Fault Location Equipment *1	set	1	
C	Others			
1.1	DC Equipment	set	1	
1.2	Panel LVAC	set	1	
1.3	Communication and SCADA	set	1	

*1; Extension of function

Source: JICA study team