	1 hour	235 (0.12 ppm)

Source: Air Quality Standards, 2005
http://www.case-moef.gov.bd/file_zone/reports_publications/BGD%20AQ%20and%20VES%20standard_BW.pdf

'Standards for Gaseous Emission from Industries or Projects' have been laid down in *Schedule 11* of the ECR, 1997. The emission standards pertaining to the power plant have been illustrated in the following ***Table 3-7.***

Table 3-7:'Standards for Gaseous Emission from Industries or Projects in Bangladesh

S.No	Parameter	Standard
1.	Particulate for a power plant with capacity of 200 MW or above	150 mg/Nm^3
2.	Lowest stack height for sulphuric acid dispersion for coal based power plant of capacity 500 MW or above	275 m
Gaseous emission from Boiler (coal based) of Industrial Unit		
3.	Soot and particulate	500 mg/Nm^3
4.	Oxides of Nitrogen (NO_x)	600 mg/Nm^3

Source: Schedule 11 of the ECR, 1997

The air quality guidelines as prescribed by IFC's EHS guidelines (December 2008 are provided in ***Table 3-8.***

Table 3-8: IFC prescribed Ambient Air Quality Guidelines

Parameter	Averaging Period	Guideline value in µg/m^3
Sulphur Dioxide (SO2)	24 hour	125 (Interim Target – 1) 50 (Interim Target – 2) 20* (Guideline)
	10 minute	500
Nitrogen dioxide (NO2)	1-year	40
	1-hour	200
Particulate Matter PM10	1 Year	70 (Interim Target – 1) 50 (Interim Target – 2) 30 (Interim Target – 3) 20 (Guideline)
	24 hour	150 (Interim Target – 1) 100 (Interim Target – 2) 75 (Interim Target – 3) 50 (Guideline)
Particulate Matter PM2.5	1 Year	35 (Interim Target – 1) 25 (Interim Target – 2) 15 (Interim Target – 3) 10 (Guideline)
	24 hour	75 (Interim Target – 1) 50 (Interim Target – 2) 37.5 (Interim Target – 3) 25 (Guideline)

Ozone	8-hour daily maximum	160 (Interim Target -1)) 100 (Guideline)

** Interim targets are provided in recognition of the need for a staged approach to achieving the recommended guidelines*

As per the Environmental, Health & Safety guidelines (for Thermal power plant) prescribed by IFC, an air shed where increment limits of pollutants are within the National Ambient Air Quality Standards is referred to as a ***Non-Degraded Air Shed.*** It is to be noted that for all air quality assessments, the more stringent guideline of the national air quality standards of Bangladesh and Interim target – 1 provided by IFC has been used.

The emission guidelines applicable for new facilities as laid down in the IFC's Environmental, Health, and Safety Guidelines for Thermal Power Plants are presented in the Table below:

Table 3-9: Emissions Guidelines (in mg/Nm^3 or as indicated)

S.No.	Combustion Technology/Fuel	Particulate Matter (PM)		Sulphur Dioxide (SO2)		Nitrogen Oxides (NOx)	
	Boiler	NDA	DA	NDA	DA	NDA	DA
1.	Natural Gas	N/A	N/A	N/A	N/A	240	240
2.	Other Gaseous fuels	50	30	400	400	240	240
3.	Liquid Fuels (Plant >50 MWth to <600 MWth)	50	30	900-1500[a]	400	400	200
4.	Liquid Fuels (Plant >/=600 MWth)	50	30	200-850[b]	200	400	200
5.	Solid Fuels (Plant >50 MWth to <600 MWth)	50	30	900-1500[a]	400	510[c] Or up to 1,100 if volatile matter of fuel < 10%	200
6.	Solid Fuels (Plant >/=600 MWth)	50	30	200-850[b]	200		

General notes:

MWth = Megawatt thermal input on HHV basis; N/A = not applicable; NDA = Non-degraded airshed; DA = Degraded airshed (poor air quality); Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded. MWth category is to apply to the entire facility consisting of multiple units that are reasonably considered to be emitted from a common stack. Guideline limits apply to facilities operating more than 500 hours per year.

- Targeting the lower guidelines values and recognizing issues related to quality of available fuel, cost effectiveness of controls on smaller units, and the potential for higher energy conversion efficiencies (FGD may consume between 0.5% and 1.6% of electricity generated by the plant).
- Targeting the lower guidelines values and recognizing variability in approaches to the management of SO2 emissions (fuel quality vs. use of secondary controls) and the potential for higher energy conversion efficiencies (FGD may consume between 0.5% and 1.6% of electricity generated by the plant). Larger plants are expected to have additional emission control measures. Selection of the emission level in the range is to be determined by EA considering the project's sustainability, development impact, and cost-benefit of the pollution control performance.
- Stoker boilers may require different emissions values which should be evaluated on a case-by-case basis

through the EA process.

Source: IFC EHS Guidelines on Thermal Power Plants

As per the Environmental, Health & Safety guidelines (for Thermal power plant) prescribed by IFC, Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded and vice versa. It is to be noted that for all air quality assessments, the more stringent guideline of the national air quality standards of Bangladesh and Interim target – 1 provided by IFC has been used.

Table below shows the comparison between limits of ambient air quality as prescribed by IFC with standards as stipulated in Environment Conservation Rules, 1997.

Table 3-10: Comparison between IFC prescribed Ambient Air Quality Guidelines and standards of ECR 1997

Parameter	Averaging Period	Guideline value in µg/m^3	Averaging Time	Concentration µg/m^3
Sulphur Dioxide (SO2)	24 hour	125 (Interim Target – 1) 50 (Interim Target – 2) 20* (Guideline)	24 hour	365 (0.14 ppm)
	10 minute	500	Annual	80 (0.03 ppm)
Nitrogen dioxide (NO2)	1-year	40	Annual	100 (0.053 ppm)
	1-hour	200		
Particulate Matter PM10	1 Year	70 (Interim Target – 1) 50 (Interim Target – 2) 30 (Interim Target – 3) 20 (Guideline)	Annual	50
	24 hour	150 (Interim Target – 1) 100 (Interim Target – 2) 75 (Interim Target – 3) 50 (Guideline)	24 hours	150
Particulate Matter PM2.5	1 Year	35 (Interim Target – 1) 25 (Interim Target – 2) 15 (Interim Target – 3) 10 (Guideline)	Annual	15
	24 hour	75 (Interim Target – 1) 50 (Interim Target – 2) 37.5 (Interim Target – 3) 25 (Guideline)	24 hours	65
Suspended Particulate Matter (SPM) (µg/m^3)	--	--	8 hours	200
Ozone	8-hour daily maximum	160 (Interim Target -1)) 100 (Guideline)	8 hours	157 (0.08 ppm)
			1 hour	235 (0.12 ppm)

Carbon Monoxide (CO) (mg/m^3)	--	--	8 hours	10 (9 ppm)
			1 hour	40 (35 ppm)
Lead (Pb) ($\mu g/m^3$)	--	--	Annual	0.5

** Interim targets are provided in recognition of the need for a staged approach to achieving the recommended guidelines*

Source: Air Quality Standards, 2005

3.8.2 Water quality standards

As per Schedule 12 of the ECR 1997, designated best use classification has been prescribed for inland surface water as given in table below.

Table 3-11: Standards for inland surface water

S.N	Best Practice based classification	Parameter			
		pH	BOD mg/l	DO mg/l	Total Coliform number/100
a.	Source of drinking water for supply only after disinfecting	6.5-8.5	2 or less	6 or above	50 or less
b.	Water usable for recreational activity	6.5 – 8.5	3 or less	5 of more	200 or less
c.	Source of drinking water for supply after conventional treatment	6.5 – 8.5	6 of less	6 or more	5000 or less
d.	Water usable by fisheries	6.5 – 8.5	6 of less	5 or more	---
e.	Water usable by various process and cooling industries	6.5 – 8.5	10 or less	5 or more	5000 or less
f.	Water usable for irrigation	6.5 – 8.5	10 or less	5 or more	1000 or less

Notes:

1. *In water used for pisiculture, maximum limit of presence of ammonia as Nitrogen is 1.2 mg/l.*
2. *Electrical conductivity for irrigation water – 2250 µ mhoms/cm (at a temperature of 25 ° C); Sodium less than 26%; boron less than 0.2%.*

As per the IFC EHS guidelines, the treated sewage discharge is required to meet the following guidelines.

Table 3-12: Treated Sewage Discharge Guidelines of IFC

S.N	Parameter	Guideline Value
1.	pH	6-9
2.	BOD	30mg/l,
3.	COD	125mg/l,

4.	Total Nitrogen	125 mg/l,
5.	Oil and Grease	10 mg/l,
6.	Total Suspended Solids	50 mg/l and
7.	Total coliform bacteria	400 MPN/100 ml

Source: General EHS Guidelines, IFC

Guideline values for process emissions and effluents in the sector of Thermal Plants as prescribed by IFC are indicative of good international industry practice as reflected in standards of countries with recognized regulatory frameworks. These levels should be achieved, without dilution, at least 95 % of the time that the plant is operating, to be calculated as a proportion of annual operating hours. Table below presents the guideline value of effluents.

Table 3-13: Specific Effluent Guidelines of IFC

Parameter	**Unit** **mg/L, except pH and temp**
pH	6 – 9
Total Suspended Solids (TSS)	50
Oil and grease	10
Total residual chlorine	0.2
Chromium - Total (Cr)	0.5
Copper (Cu)	0.5
Iron (Fe)	1.0
Zinc (Zn)	1.0
Lead (Pb)	0.5
Cadmium (Cd)	0.1
Mercury (Hg)	0.005
Arsenic (As)	0.5
Temperature increase by thermal discharge from cooling system	Elevated temperature areas due to discharge of once-through cooling water (e.g., 1 Celsius above, 2 Celsius above, 3 Celsius above ambient water temperature) should be minimized by adjusting intake and outfall design through the project specific EA depending on the sensitive aquatic ecosystems around the discharge point.

Note:

1. To be applicable at relevant wastewater stream: e.g., from FGD system, wet ash transport, washing boiler / air preheater and precipitator, boiler acid washing, regeneration of demineralizers and condensate polishers, oil-separated water, site drainage, coal pile runoff, and cooling water).

2. Guideline limits in the Table are from various references of effluent performance by thermal power plants.

As per Schedule X of ECR Rules 1997 as prescribed by DoE of Bangladesh, temperature limit for hot water discharge of industrial waste is 40°C.

3.8.3 Ambient noise standards

The MoEF under the provisions of ECR, 1997 is responsible for laying down ambient noise standards. Noise Pollution (Control) Rules, 2006 were laid down by the Ministry through a Gazette notification dated September 7, 2006. Ambient noise standards established as per the provisions Rule 5(2) of the aforementioned Rules have been furnished in the following ***Table 3-14.***

Table 3-14: Ambient noise standards

S.No.	Type of Area	Limits in dB(A) L_{eq}	
		Day	Night
1.	Silent Zone	50	40
2.	Residential area	55	45
3.	Mixed area	60	50
4.	Commercial area	70	60
5.	Industrial area	75	70

Note:

1. *dB(A) L_{eq} represents time-weighted average noise level on the Decibel-A scale*
2. *Day time is from 6am to 9pm, Night time is form 9pm to 6 am*
3. *Mixed area is mainly residential area, and also simultaneously used for commercial and industrial purposes*
4. *Area up to a radius of 100 m around hospitals/educational institutions/special institutions/ establishments identified/to be identified by the Government is designated as Silent Zones where use of horns of vehicles or other audio signals, and loudspeakers are prohibited.*

As per IFC EHS Guidelines, noise impacts should not exceed the levels presented in ***Table 3-15*** below, or result in a maximum increase in background levels of 3 dBA at the nearest receptor location off-site.

Table 3-15: Noise Level Guidelines

Receptor	One Hour L_{Aeq} (dBA)	
	Daytime 07:00 - 22:00	Night time 22:00 - 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

3.9 Applicable International Conventions

Environmental problems which migrate beyond the jurisdiction (Trans-boundary) require power to control such issues through international co-operation by either becoming a Contracting Party (CP) i.e. ratifying treaties or as a Signatory by officially signing the treaties and agreeing to carry out provisions of various treaties on environment and social safeguards. Bangladesh has signed and ratified several Multilateral Environmental Agreements (MEAs), International Labour Organisation (ILO) Conventions and international maritime conventions. The relevant international conventions have been summarized in the ***Table 3-16.***

Table 3-16: Applicable International Conventions

S.No	International Conventions	Salient Features
Multilateral Environmental Agreements (MEA)		
1.	Rio Declaration, 1992	Bangladesh is a signatory to Principle 4 of the declaration

S.No	International Conventions	Salient Features
		1992 a global action program for sustainable development called *Rio Declaration* and *Agenda 21* was adopted in the annual United Nations Conference on Environment and Development (UNCED) held in Rio De Janeiro, Brazil.
2.	Convention on Biological Diversity, 1992	It was adopted on June 5, 1992. The signatory has an obligation of: • Introducing appropriate procedures requiring environmental impact assessments of its proposed projects that are likely to have significant adverse effects on biodiversity, with a view to avoiding or minimizing such effects, and where appropriate allow for public participation in such procedures; and • Introducing appropriate arrangements to ensure that environmental consequences of its programs and policies, that are likely to have significant adverse impacts on biodiversity, are duly taken into account. As per the convention, ESIA shall consider impacts on biodiversity due to project activities.
3.	Convention on Wetlands of International Importance Especially as Waterfowl Habitat, Ramsar (1971)	This is an intergovernmental treaty, which provides the framework for international co-operation for the conservation of wetlands habitats. Obligations for Contracting Parties include the designation of wetlands to the "List of Wetlands of International Importance', the provision of wetland considerations within their national land use planning, and the creation of Natural Reserves. Parts of Sundarbans Reserved Forest (Southwest of Bangladesh) are one of the Ramsar Sites.
4.	United Nations Convention on the Law of the Sea, Montego Bay, (1982)	Main objectives of the convention are: • To set up a comprehensive new legal regime for the sea and oceans, as far as environmental provisions are concerned, to establish material rules concerning environmental standards as well as enforcement provisions dealing with pollution of the marine environment; and • To establish basic environmental protection principals and rules on global and regional co-operation, technical assistance, monitoring, and environmental assessment, and adoption and enforcement of international rules and standards and national legislation with respect to all sources of marine pollution.
International Labour Organisation (ILO) Conventions		
1.	International Labour Organisation Conventions	Bangladesh has ratified many of the International Labour Organization conventions that are relevant to the Project

S.No	International Conventions	Salient Features
		including: • C1 Hours of Work (Industry) Convention, 1919 (14:07:1921, ratified); • C5 Minimum Age (Industry) Convention, 1919 (09:09:1955, ratified): • C11 Right of Association (Agriculture) Convention, 1921 (11:05:1923, ratified): • C14 Weekly Rest (Industry) Convention, 1921 (11:05:1923, ratified); • C29 Forced Labour Convention, 1930 (30:11:1954, ratified) & C105 Abolition of Forced Labour Convention, 1957 (18:05:2000, ratified); • C100 Equal Remuneration Convention, 1951 (25:09:1958, ratified); • C107 Indigenous and Tribal Populations Convention, 1957 • C111 discrimination (Employment and Occupation) Convention, 1958 (03:06:1960, ratified)This Convention limits the hours of work in industrial undertaking to eight (8) in the day and forty-eight (48) in the week
Maritime Conventions, Protocols and Agreements		
1.	Safety of Life at Sea (SOLAS) Convention, 1974	This convention is related to specification of minimum standards for the construction, equipment and operation of ships, compatible with their safety. *Has been implemented since November 4, 2002.*
2.	Load Lines Convention, 1966	It's related to limitations on the draught to which a ship may be loaded to ensure its safety. The Protocol of the Load Line Convention was acceded by GoB on November 4, 2002.
3.	International Convention for the Prevention of Pollution from Ships (MARPOL)	The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively and also includes the Protocol of 1997 (Annex VI). It has been updated by amendments through the years. MARPOL 73/78 (Annex-I, II, III, IV, V and VI) *Has been implemented since November 4, 2002*
4.	Convention for The Suppression of Unlawful Acts of Violence Against the Safety of Maritime Navigation (SUA convention), 1988	Its main purpose is to provide protection against unlawful acts of violence and penalised perpetrators of such acts. The unlawful acts include: • The seizure of ships by force; • Acts of violence against persons on board ships; and • The placing of devices on board a ship which are likely to destroy or damage it. The convention mandates the signatories either to

S.No	International Conventions	Salient Features
		extradite or prosecute alleged offenders. The Convention came into force in Bangladesh on September 7, 2005.
Multilateral Environmental Agreements (MEA)		
5.	Kyoto Protocol	The protocol is aimed at reducing greenhouse gas (GHG) emissions from various industrial activities and curbing its effects on the environment. Seven GHGs have been identified for targeted emission reduction namely: • Carbon dioxide (CO_2) • Methane (CH_4) • Sulphur hexafluoride (SF_6) • Nitrous Oxide (N_2O) • Nitrogen trifluoride (NF_3) • Hydrofluorocarbons (HFCs) • Perfluorocarbons (PFC) The parties to the protocol shall reduce their GHG emissions through one or more of the three flexible mechanisms laid down under the protocol viz. : 1. Clean Development Mechanism 2. Joint Implementation 3. International Emissions Trading The protocol formulated in 1997 and came into force in 2008. It's currently under its second commitment period which terminates in 2020. Bangladesh signed the protocol October 22, 2001. However, it has no binding emission reduction target as it's a developing nation.
6.	Basel Convention on the Control of Trans boundary Movements of Hazardous Wastes and Their Disposal	It was formulated to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries (LDCs). It does not, however, address the movement of radioactive waste. The Convention is also intended to minimize the amount and toxicity of wastes generated, to ensure their environmentally sound management as closely as possible to the source of generation, and to assist LDCs in environmentally sound management of the hazardous and other wastes they generate. The wastes under the Convention's scope are listed under its Annex – I, II and III. In addition to conditions on the import and export of wastes, there are stringent requirements for notice, consent and tracking for movement of wastes across national boundaries. The Convention came into force on May 5, 1992.

S.No	International Conventions	Salient Features
		Bangladesh acceded it on April 1, 1993.

Source: Assessment of International Conventions applicable in Bangladesh

4. Project Data Sheet

This section of the report provides the details about the project proponent, location, concept and details pertaining to procurement of land. It also provides a description of project components along with associated facilities. The resource requirements and pollution control systems proposed have also been discussed.

4.1 Project Proponent

Orion Power Unit-2 Dhaka Limited proposes to develop a coal based power plant in Munshiganj District, Bangladesh, is the project proponent. The project site is located at a distance of about 40 km from Dhaka in the southeast direction.

BPDB had issued a Letter of Intent to Orion Group to design, finance, construct, own, commission and maintain coal based power plant (CPP) in Munshiganj district of Bangladesh for a period of 25 years .The Project is an Independent Power Producer (IPP) Project allocated to the Orion Group by the Bangladesh Power Development Board (BPDB), Government of Bangladesh (GOB).

4.2 Project Location and Area

The proposed project site comprises of land from Bhati Balakia and Char Balakia villages falling under Char Betaki Mauza. The site is located within Hoessendi Union of Gazaria Upzila (Sub-district), Munshiganj district of Bangladesh. The site is situated to the south of a V- shaped island formed due to meandering of River Meghna from its main course. The site is located at an elevation of about 2-5 m above mean sea level (amsl), with Meghna River and its tributary, Dhaleshwari flowing to its east and west borders respectively.

The site is located at a distance of about 5.3 km from Dhaka–Chittagong Highway (N1) in the south west direction. At present, the site is not accessible by roads and can be approached only through country boats plying from Meghna Ferry Ghat which is at a distance of about 5 km from the project site. The nearest airport is Dhaka airport at a distance of 40 km and the nearest port is Chittagong port at a distance of 240 km from the project site. The coal will be transported via Chandpur to the proposed site. The coordinates of the site are presented in *Figure 4-1*. The physical features map of the site has been illustrated in *Figure 4-2.*

Figure 4-1 : Geographical Coordinates of Site

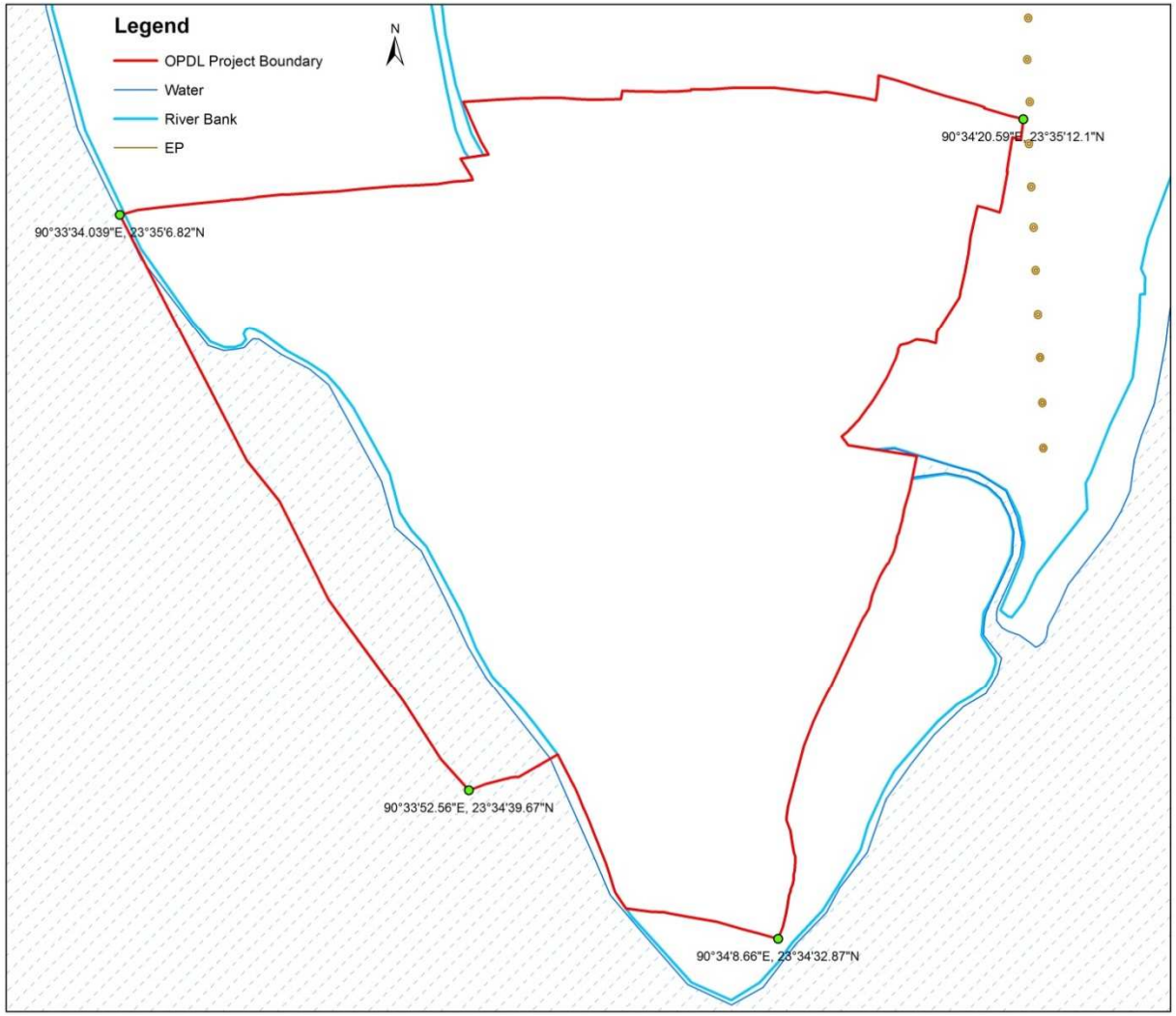
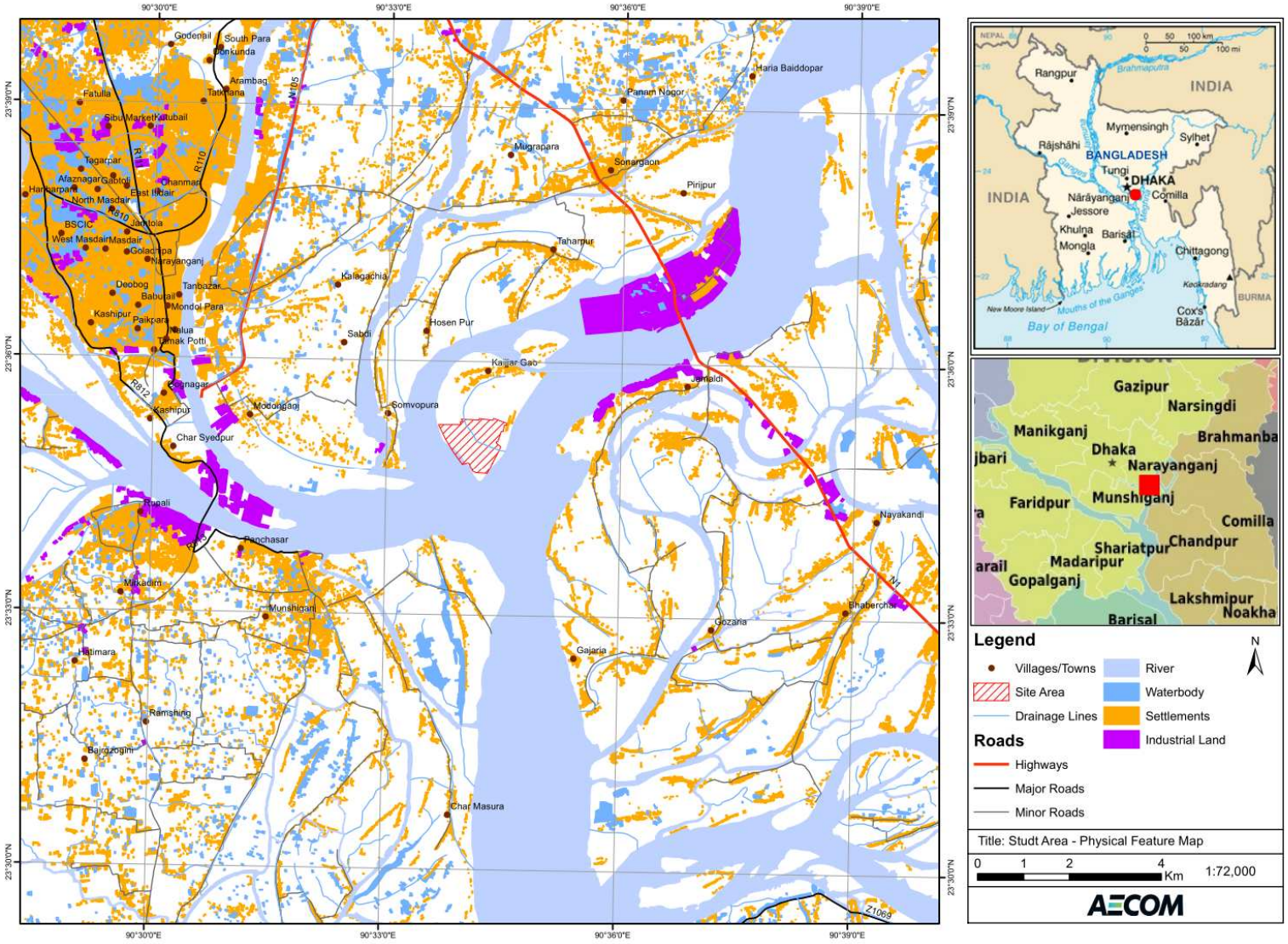


Figure 4-2: Site Connectivity



4.3 Nature and Size of the Project

The power plant will be based on ultra-supercritical technology with a gross and net power generation capacity of 680 MW and 635 MW respectively. The plant will comprise of one boiler and one steam turbine unit. The coal for the project will be sourced from Australia and Indonesia and will be bought to the Chittagong port in mother vessels and will be discharged to lighters. The cooling water for the project will be sourced from Meghna River. The power generated will be evacuated to the nearest Bangladesh Power Development Board's substation located at about 3.5 km away from the proposed project site.

4.4 Project Concept

A general layout plan for the proposed plant based on the feasibility study has been provided in *Figure 4-3*. The layout has been developed considering the availability of land, ground features and location of environment and social sensitive receptors. The detail layout plan showing all structures, road network, drainage network, different pollution abatement measures, and water, waste water and effluent treatment facilities will be developed by the EPC contractor before construction. The EPC contractor shall be appointed by OPDL-2 after receiving the Environmental Clearance Certificate from the Department of Environment. Master Layout for the proposed project has been attached as Annexure B.

Figure 4-3: Proposed Plant Layout

The plan has been prepared with an objective to minimise the footprint so as to reduce the quantity of filling by dredging. The jetty for fuel loading unloading has been proposed along the East boundary of the plot. The covered coal yard has been proposed in the close proximity of the coal yard in the north direction considering the predominant wind direction and the distance from settlements. The milling house is located next to the boiler plant. Permanent facilities like workshop, permanent stores, etc. are located close to the main plant. The ash slurry/ash water pump house is kept towards the chimney and Flue Gas Desulfurization (FGD) space, for future development, is kept beyond the chimney. Adequate space has been kept in the layout plan for lay-down and pre-assembling activities of open stores, contractor's offices and stores etc. Construction offices and storage sheds are located close to the main approach road to the plant. Administrative building is proposed to be located outside the plant boundary near the main approach road. The following major components have been included in the layout plan:

- Industrial (plant area)
- Main power plant (boiler, turbine, Generator, Workshop Store, etc.)
- Electrostatic Precipitator, Flue Gas Desulfurization (FGD) as required, and Chimney
- Induced Draft Cooling Tower
- Greenbelt and open space
- Open air sub-station and network control room
- Coal terminal including jetty & coal conveyer belt
- Ash handling control room, ash silo, ash disposal area

4.5 Project Components

The proposed project comprises of one coal based power generation unit of 635 MW net capacities. Two additional units of 635 MW each may be installed at a later stage and area has been earmarked for these units. The key basic plant information has been presented in *Table 4-1* and the details of project components have been provided below.

Table 4-1: Basic Plant Information

Component	Design condition
Plant Configuration	Ultra-supercritical PC (Pulverised Coal)
Carbon capture	Nil
Gross power output	680 MW
Net power output	635 MW
Plant Load Factor	85 %
Primary fuel (type)	Bituminous and Sub-bituminous Coal having GCV of 26,050 KJ/Kg (after mixing) and Sulfur content (0.9%)
Source of fuel	Coal will be imported from Australia and Indonesia
Coal Consumption	212 tonnes/hour (at 100% plant load factor)
Land Area	112 acres of Private Land (1x 635MW)
Stack height	275 m
Water Intake (Make up water)	80140 m^3/hr
Water discharge after treatment	80000 m^3/hr
Water consumed	140m^3/hr

Source: Detailed Project Report, Orion

4.5.1 Fuel Handling and Storage System

4.5.1.1 Coal Requirement and Specifications

The coal requirement for the project has been estimated as follows:

- Consumption, per hour 212 Tonnes/hour
- Consumption, per day 5088 Tonnes/day
- Consumption, per year 1484000 Tonnes/year

The coal for the proposed project will be sourced from Australia and Indonesia. The specifications of the main fuel, coal have been provided in *Table 4-2*

Table 4-2: Coal Specifications

S.N	Parameter	Unit	Design Coal	Coal Range
1	Heat Value	Btu/lb	11200	8000-11500
2	Calorific Value	KJ/kg	26050	26050 – 30150
3	Volatile Matter	%	33.1	22 – 40
4	Carbon, C Fixed (proximate)	%	42.0	40 – 65
5	Carbon, C Fixed (ultimate)	%	61.1	59 – 70
6	Hydrogen	%	4.6	3.5-5.0
7	Oxygen	%	8.0	5.9-13.0
8	Water Content	%	15.0	6.5-17.0
9	Nitrogen	%	1.4	1.1-1.7
10	Sulphur	%	0.6	<0.84
11	Ash Content	%	9.0	3.5-15.0
12	Chloride content	%	0.02	0.0- 0.03
13	Hardgrove index	HGI	50	45- 61

Source: OPDL-2

The plant should be able to operate steadily in island mode operation for at least three hours. Estimated annual operation hours of the plant are 8000 hours/year.

4.5.1.2 Coal Systems

The coal will be transported to the site in barges. The unloading facility will comprise of barge unloaders. The wharf will be provided with 6 shore cranes of 25tonne capacity each fitted with 8 tonne grabs. The facility will be equipped to have berthing and unloading of 5 vessels at any one time and 1 crane under preventative care and maintenance. One floating barge crane of 25 tonne capacity fitted with an 8 ton grab will be provided on standby for emergency and rescue situations.

The coal will be conveyed from the wharf to the coal yard by means of belt conveyor. To avoid impurities in the coal, which may damage the belt conveyor system, a magnetic separator and crusher will be installed. The coal yard will have a minimum capacity of 300,000 tonnes, which is equivalent to 90 days of coal consumption. Coal will be collected by dozers and conveyed from coal yard to silos. The coal yard will be covered against rainfall and appropriate drainage shall be provided.

The coal yard will be provided with a run off pit with drains around the coal yard. During monsoon, the rain water from the coal pile will be collected in drains and led to the coal pile run off pit. The run off pit will be equipped to separate out the coal particles from the runoff and this coal will be dumped in coal yard.

Automatic dust detectors will be provided in the coal yard. The coal yard will have a dust suppression system and spray heads of swivelling spray units located at a distance of minimum 40 meters around the coal yard will be provided.

4.5.2 Fuel Oil Systems

The fuel oil handling and storage system will include unloading, storage and transfer of fuels to the oil tanks. Light diesel oil (LDO) will be used for the cold start of boiler load up to 7.5 % Boiler Maximum Continuous Rating (BMCR) and for auxiliary steam boiler. Heavy fuel oil (HFO) will be used for start-up of the boiler and during low load up to 35% BMCR. HFO will also be used for flame stabilization during low load.

The fuel oil will arrive over a floating jetty and will be unloaded directly into the storage tanks. Two storage tanks of 2,000 tons and one tank of 500 ton capacity will be provided for HFO and LDO respectively. All oil storage tanks will be provided with secondary containment and oil traps of adequate capacity to control any accidental leaks.

4.5.3 Boiler

The proposed plant will comprise of a opposed wall fired Benson once through two pass radiant-type super critical boiler with a super heater steam system and a single reheat steam system and will be able to operate in sliding pressure mode. The superheat steam temperature will be controlled by means of water injection whereas the reheat steam temperature will primarily be controlled by means of flue gas recirculation over the load range. Attemperating water injection for reheat steam temperature control will be minimized and only used as secondary system.

The rated steam conditions at Boiler Maximum Continuous Rating (BMCR) will be as follows:

1	High pressure superheat steam outlet pressure:	250 bar
2	High pressure superheat steam outlet temperature	580˚C
3	High pressure superheat steam flow outlet boiler	538.9 kg/sec
4	Cold reheat steam pressure, outlet HP turbine	60.3 bar
5	Cold reheat steam temperature	362 ˚C
6	Hot reheat steam pressure, inlet IP turbine	56.60 bar
7	Hot reheat steam temperature	595 ˚C
8	Hot reheat steam flow outlet boiler	452.5 kg/sec
9	Feed water final temperature	310 ˚C

	inlet boiler	

Source: OPDL-2

4.5.3.1 Air – Flue Gas System

The air intake will be as per the ambient design condition (i.e. Temperature – 7 to 42 ˚C, Relative Humidity – 40-70%) and pressure of 1013 mbar. The flue gas inlet temperature to the Electro Static Precipitator will be 120˚C. Two forced draft (FD) fans will be provided to supply secondary air to the furnace to assist in combustion.

4.5.3.2 Combustion System

The system will be equipped with coal mills and coal silos, so that the boiler can operate at full load, BMCR. Each coal silo will have a storage capacity for 12 hours operation at BMCR.

The coal silo will have a normal outlet to the coal feeder and an emergency outlet to make it possible to empty the silo down on floor level in trucks in case of error to the silo system. The mills will be equipped with rotating classifiers and meet the design coal specifications. The boiler will be equipped with low NOx burners to reduce primary NOx.

4.5.4 Steam Turbine Unit

The steam turbine will receive steam from the boiler unit and will run at a speed of 3000 revolutions per minute (RPM). The turbine will be directly coupled to a synchronous generator to generate power. The steam turbine will be provided with necessary number of regenerative extraction/bleed points. After expansion in the HP turbine, part of the HP exhaust will be taken to the HP heater for feed water pre-heating and remaining part will be directed to the reheater for reheating and then to IP and LP sections of the turbine for further expansion.

The turbine unit will have the following performance conditions at Turbine Maximum Continuous Rating (TMCR).

- Preliminary gross output 680 MW
- Internal Consumption 50 MW
- Net power output (minimum) 635 MW

4.5.4.1 Condensate and Feed water Preheat Train

The turbine unit will be provided with five (5) low pressure hearer steps, one (1) de-aerator and storage tank, four (4) high pressure heater steps and one (1) high pressure de super heater.

The condensate pre heater train is expected to consist of 5 pre heaters, including the Drain Cooled. Feed water to the boiler will be de-aerated in the feed water tank to remove the dissolved oxygen up to specified levels in order to avoid water side corrosion of boiler tubes.

4.5.5 Cooling Water Systems

The cooling water system provides the water for condenser. The main cooling water system for the proposed plant is a once through cycle (OTC). The inlet water will be drawn from Meghna River. A tapping from the main cooling water system inlet part will provide auxiliary cooling water and the heated auxiliary cooling water will be discharged back to the Meghna River. The intake point for water withdrawal will comprise of the following:

- Coarse bar screen with a mechanical cleaning function to prevent entry of mechanical debris and biological species in the inlet channel

- Fish avoidance system to prevent fish from entering the inlet channel
- Waste disposal system from the coarse bar screen

Both the inlet and the outlet channel will be protected against flooding by having a dyke wall at both sides integrated in the channel side wall and at the dyke crossings.

4.5.6 Electrical and I&C (Instrumentation and Control) Systems

The steam turbine generator will be rated to deliver 635 MW net power, with 0.8 lagging and 0.95 led Power Factor and 50 Hz frequency at the plants delivery point. The generator will be connected to the 400 KV switchyard through a Step-up transformer. The power will be evacuated from the 400 KV Switchyard through line feeders. The start-up power will be normally drawn from the grid (proposed 400 KV lines) through station transformer and Diesel Generator (DG) sets shall be provided for the black start of the plant. The size of the DG sets will be decided based on the power required for starting the plant.

The auxiliary power supply will be through 11kV and 400V lines and two (2) transformer units will be provided. The power supply for unit transformers will be tapped from the main run of the isolated phase bus duct.

4.6 Project Activities- Construction Phase

The construction phase of the proposed Project will involve land survey, geotechnical investigation, component delivery; construction of access roads, foundations, erection of boiler units, plant structures boilers, generators, turbines, storage tanks, welding/cutting onsite, installation of heavy machinery, pumps and mechanical and electrical installations. The construction works will also entail site clearance, filling and levelling works along with development of material storage yards. The section below describes the various aspects involved in the construction phase of the project.

4.6.1 Project Schedule

The project completion is scheduled in about 45 months from the commencement of construction activities to plant commissioning. The work plan of implementation (Implementation Schedule) is provided in *Table 4-3.*

Table 4-3: Project schedule

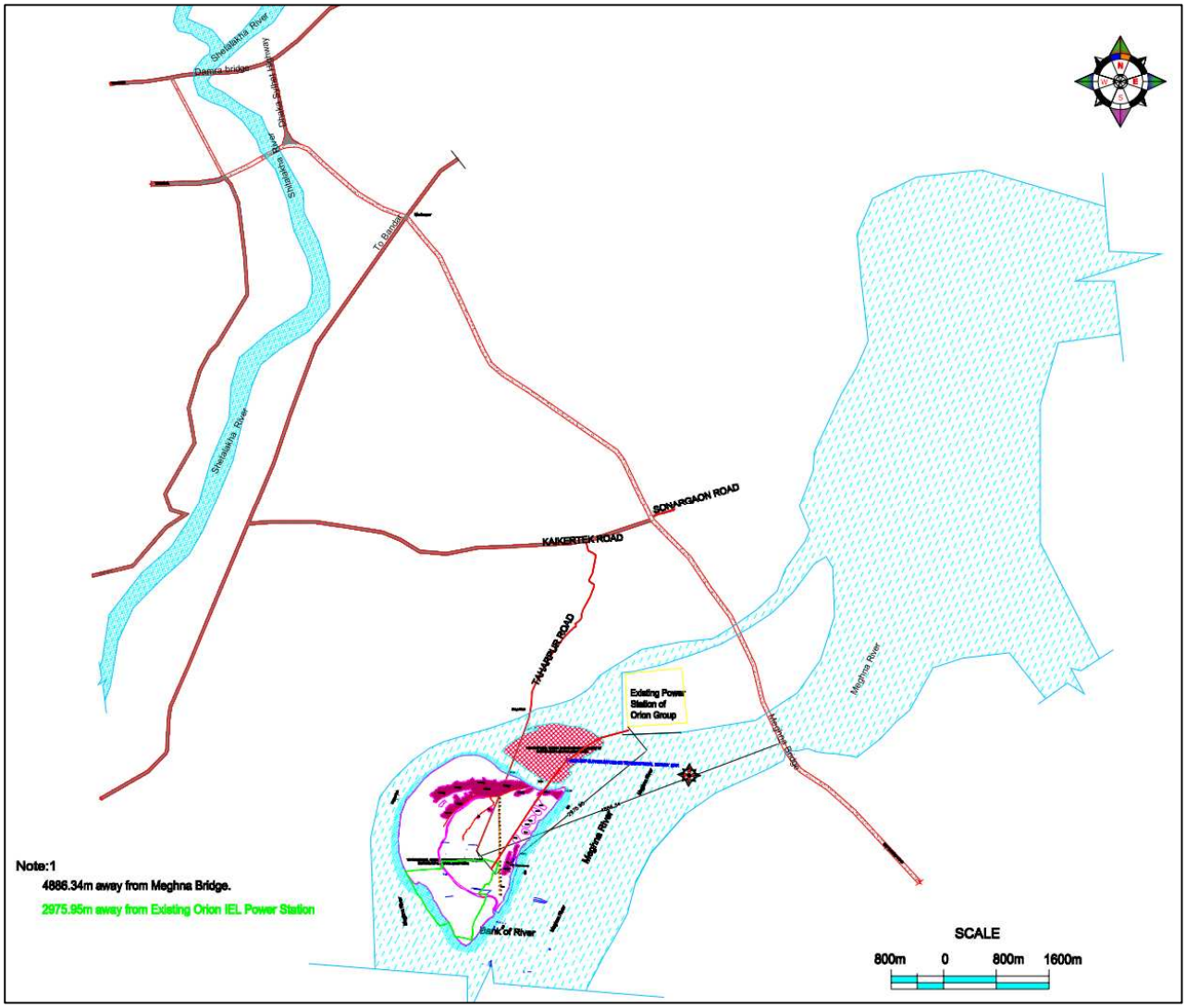
S.N	Activity	Expected Date
1	Commencement of construction activities	End of 2014
2	Completion of construction works	End of 2018
3	Trial production	Start of 2019

Source: OPDL-2

4.6.2 Access Roads

The proposed project will involve construction of two access roads to provide connectivity to existing Tarapur road and existing Orion Group's power plant. The length of the road will be 2.5 km and 3.1 km respectively and will be bitumen road. The details of the proposed roads are presented in Figure 4-4.

Figure 4-4: Proposed Access Roads



4.6.3 Labour

During construction phase, the labour requirement will range from 1000 – 1500 during normal operations and 2500-3000 workers for peak construction activities. There will be a significant influx of labour during the construction phase and it is expected that during the peak construction activities, about 1000-2000 migrant workers will be accommodated in labour camps.

4.6.4 Water and Wastewater

The water demand for the construction works will be about 40 m^3/hour to 100 m^3/hour during normal and peak demand respectively and will be sourced from Meghna River after obtaining due approval from Bangladesh Inland Water Transport Authority. The potable water requirement will range from 90 KLD – 180 KLD and will also be sourced from Meghna River. Suitable treatment will be provided for drinking water. The wastewater generated will be treated in a temporary sewage treatment system and discharged to Meghna River in compliance with the discharge norms.

4.6.5 Waste Generation

The construction activities will lead to generation of wastes such as construction debris, waste from packaging and crafting material for project components. The waste will be disposed of through DoE approved vendors. The movement of heavy machinery for site clearance, earth moving, transportation and erection will generate waste oil, hydraulic oil, lubricants, paints, degreasers and gearbox oil. Waste oil is classified as a hazardous waste and will also be disposed of through a DoE approved vendor.

4.7 Power Evacuation System

The power generated will be evacuated through 230 kV transmission lines to the Meghnaghat substation of Bangladesh Power Development Board located at a distance of about 3.5 km from site. The transmission line will pass over the Meghna River and one or two transmission towers may be constructed in the river by Bangladesh Power Development Board. This transmission line will then connect to the 400 kVA national grid line and finally connect to the existi8ng Meghnaghat Substation. The transmission line layout has been presented in Figure 4-5.

Figure 4-5: Power Evacuation Line from Proposed Plant to National Grid

Source: OPDL-2

4.8 Resources and Utilities Demand

4.8.1 Water and Wastewater Treatment Systems

The proposed project will require water with varied degree of treatment/processing such as clarified and treated water for service water, demineralised water for boiler, condensate polishing plant regeneration and filtered disinfected water for potable water requirements.

4.8.1.1 Raw Water Treatment

Water from Meghna River will be pumped into an open reservoir with two compartments. The raw water treatment will comprise of the following processes:

- Disinfection
- Aeration
- Clarification
- Continuous sludge removal
- Final filtration

The sludge from the treatment process will be processed in a sludge dewatering system (centrifuges/ belt press filter).

The raw water treatment system has been illustrated in *Figure 4-6.*

4.8.1.2 Demineralization (DM) Plant

The Demineralisation plant will supply make-up water to the water steam cycle, condensate make up and condensate polishing regeneration. The DM plant will involve removal of mineral salts from water by ion-exchange method, consisting of cation, anion and mixed bed polisher. The regeneration effluents for the demi plant process will be discharged to neutralization pit. The pit interior surfaces and surrounding surfaces will be protected by anti-acid material lining and the pit will be equipped with means for recirculation of the contents to ensure water mixing, acid and alkali injection points and automatic pH controls and recorders. The effluent from the DM plant will be sending to waste water treatment system.

Demineralized Water Treatment System (DWTS) will be sized as following:

SL No.	Item of Usage	Calculation	m^3/h
1	Make-up to the main steam cycle (1.5 % Make-up)	1 x 2100 x 1.5%	31.5
2	Chemical Dosing, Demineralizer Regeneration, and Condensate Polisher Regeneration System dilution water		3.0
3	Laboratory demineralized water use		0.5
4	Make-up to the CCCW system (0.5 % Make-up)	1x 2000 x 0.5%	10.0

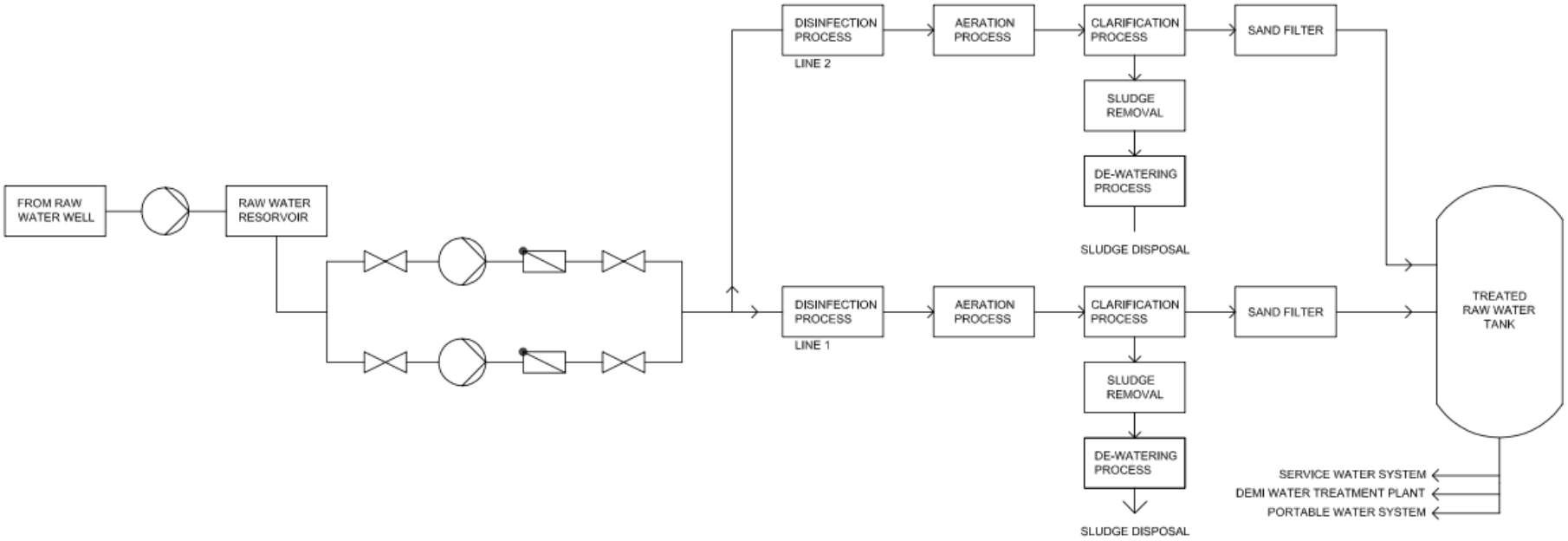
Source: OPDL-2

According to the above, the DM water requirement for the design condition is: Q=45m^3/h. DM water treatment system should be sized as 2 x 100% with each stream of 50~60m^3/h.

4.8.1.3 Potable water

A potable water treatment system will be provided to supply water for domestic consumption.

Figure 4-6: Raw Water Treatment Scheme



4.8.1.4 Waste water system

The wastewater/effluent streams from the plant will include the following:

- Effluents and process wastewater
- Domestic wastewater
- Runoff from process and other plant areas

Process Effluents

The process effluents from the proposed project will comprise of:

- **Clarifier:** Sludge from the treatment plant will be collected in a sump. Solid waste will be removed by centrifuges/ belt press filter. Clear water will be directed to the inlet of clarifier and the solid waste will be disposed by dumpers to land fill according regulations.
- **DM plant**: The regeneration waste will be neutralized in basin near DM plant. Neutralized regeneration effluent will be pumped to the collection basin.
- **Condensate polishing unit**: The regeneration waste will be collected and neutralized in a neutralization pit. The neutralized regeneration effluent will be then pumped to the collection basin.
- **Boiler blow down and other process drains**: Collected in drain tanks and reused.
- **Service waste water:** Will be treated by oil water separator, lamella or conventional/ reactor clarifier. The treated water from clarifier will be transferred to collection basin.
- **Boiler air pre-heater washing**
- **Coal pile area run offs:** Will be channelized to settling pond and the clear overflow will be pumped to the collection basin.
- **Ash disposal area run off** – Will be channelized to the settling pond and the clear overflow will be pumped to the collection basin.
- **Fuel oil storage and handling area effluent:** Oily effluent will be pumped to oil water separator,

Domestic Wastewater

Domestic waste water will be generated from the accommodation facility provided for the workers and staff during the operation. The wastewater generated will be treated in a package type sewage treatment plant (STP) and the treated water will be used for landscaping of 34% of the area of project site.

Runoff from process and other plant areas

Storm water runoff drainage network will be developed to direct runoff from roof drains and other areas to the collection basins or to natural drainage, as appropriate. The collection basins will be designed to contain general site drainage, neutralization basin flows, oil/water separator flows, and service water system flows, septic tank. The basin will be sized to contain minimum the 24 hours storm runoff from two most recent consecutive rainfall events and will be designed not to have a normal discharge. Offsite runoff entering the site from surrounding areas will be routed around the site area through the use of overland flow, open channel flow, and underground piping or a garland drain around the site.

4.8.2 Chemical Dosing System

The chemical dosing system for the plant will include systems for conditioning of the water/steam system, condenser cooling water and auxiliary steam system. The dosing system will comprise of the following:

- **Ammonia (NH_3) dosing** to condensate system, auxiliary boiler and cooling water system for pH control. The ammonia dosing system will use a 25 % ammonia solution diluted with demineralised water.
- **Oxygen dosing** to condensate system and auxiliary boiler - A bottle rack with 200 bar pressurized vapour 50 litre bottles will be installed

4.8.3 Fire Protection System

The fire protection installations and escape routes shall be designed according to Bangladesh regulations, standards and directions. The system will comprise of water firefighting system, fire extinguishers, fire extinguishing water tank and fire extinguishing water pumping station.

4.9 Source of Primary Fuels

The coal for the proposed project will be sourced from Australia and Indonesia. The specifications of the main fuel, coal have been provided in Table 4-4.

Table 4-4: Coal Specifications

S.N	Parameter	Unit	Design Coal	Coal Range
1	Heat Value	Btu/lb	11200	11200 – 12960
2	Calorific Value	KJ/kg	26050	26050 – 30150
3	Volatile Matter	%	33.1	22 – 40
4	Carbon, C Fixed (proximate)	%	42.0	40 – 65
5	Carbon, C Fixed (ultimate)	%	61.1	59 – 70
6	Hydrogen	%	4.6	3.5-5.0
7	Oxygen	%	8.0	5.9-13.0
8	Water Content	%	15.0	6.5-17.0
9	Nitrogen	%	1.4	1.1-1.7
10	Sulphur	%	0.6	<0.84
11	Ash Content	%	9.0	3.5-15.0
12	Chloride content	%	0.02	0.0- 0.03
13	Hardgrove index	HGI	50	45- 61

Source: OPDL-2

4.10 Transportation of Primary Fuels

Delivery of coal to the plant will be undertaken through Mother Vessels which will arrive directly from Chittagong which is situated at a distance of 240km approximately in south east direction from the site. The coal will be transported via Chandpur to the proposed site. Subsequently, coal will sail on the incoming tide directly to the plant wharf to fully discharge the cargo. The coal will be transported to the site in barges. The unloading facility will comprise of barge unloaders. The wharf will be provided with 6 shore cranes of 25tonne capacity each fitted with 8 tonne grabs. This completely eliminates the need for any anchorage or transfer to Lighters. Direct transfer to site will also prevent spillage of coal into sea during transfer to lighter.

The coal will be conveyed from the wharf to the coal yard by means of belt conveyor. To avoid impurities in the coal, which may damage the belt conveyor system, a magnetic separator and crusher will be installed. The coal yard will have a minimum capacity of 420,000 tonnes, which is equivalent to 90 days of coal consumption. Coal will be collected by dozers and conveyed from coal yard to silos. The coal yard will be covered against rainfall and appropriate drainage shall be provided.

5. Process Description

5.1 Project Site and Layout

The project site is located at a distance of about 40 km from Dhaka in the southeast direction. The district headquarter, Munshiganj is located at an aerial distance of about 5 km from the project site. The project site constitutes a part of a V - shaped island formed through meandering of River Meghna from its main course and is located at an elevation of 2-5 m above mean sea level. At present, the site is not approachable by road and can be accessed only through country boats.

The detail layout of the proposed project will encompass all structures, road network, drainage network, different pollution abatement measures, and water, waste water and effluent treatment facilities. The jetty for fuel loading unloading has been proposed along the East boundary of the plot. The coal yard has been proposed in the close proximity of the coal yard in the north direction considering the predominant wind direction and the distance from settlements. The milling house is located next to the boiler plant. Permanent facilities like workshop, permanent stores, etc. are located close to the main plant. The ash slurry/ash water pump house is kept towards the chimney and Flue Gas Desulfurization (FGD) space, for future development, is kept beyond the chimney. Adequate space has been kept in the layout plan for lay-down and pre-assembling activities of open stores, contractor's offices and stores etc. Construction offices and storage sheds are located close to the main approach road to the plant. Administrative building is proposed to be located outside the plant boundary near the main approach road. The following major components have been included in the layout plan:

- Industrial (plant area)
- Main power plant (boiler, turbine, Generator, Workshop Store, etc.)
- Electrostatic Precipitator, Flue Gas Desulfurization (FGD) as required, and Chimney
- Induced Draft Cooling Tower
- Greenbelt and open space
- Open air sub-station and network control room
- Coal terminal including jetty & coal conveyer belt
- Ash handling control room, ash silo, ash disposal area

5.2 Resource Requirements

5.2.1 Land

The proposed project will be spread over an area of 112 acres spread across Bhati Balakia and Char Balakia villages falling under Char Betaki Mauza. The land for the proposed project comprises of private agricultural land. The project area comprises of low lying land and is vulnerable to submergence during the monsoon season. The land has been procured on willing seller willing buyer basis and individual negotiations were carried out by OPDL-2 with the land owners.

5.2.2 Water

About 80,140 m^3/hr of surface water will be sourced from Meghna River for the proposed project.

The major demand for water will be for cooling water system and has been estimated as 80,000 m^3/hr for the proposed project. Once through cooling water system is proposed, which will involve extraction of water from the river and discharge of the heated cooling water back to the river. The circulation cooling water temperature rise will be a maximum of 8˚C from the inlet water temperature.

Other uses of water will include makeup water for boiler, water for ash handling system, greenbelt development, service water requirements for plant washing and water sprinkling for dust suppression and for domestic consumption. The breakup of the water requirement is presented in table below.

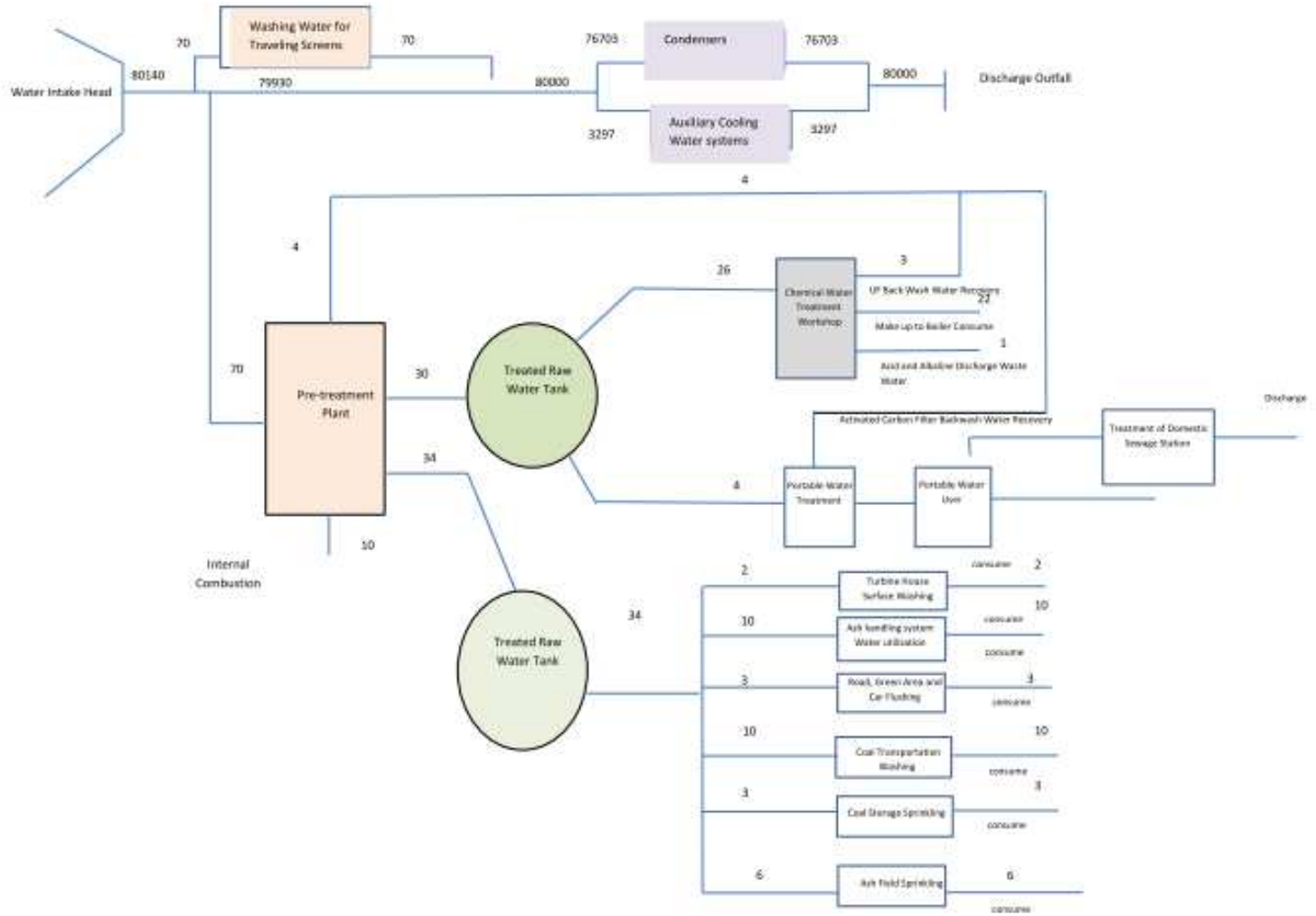
Table 5-1: Water Requirement

S.N	Activity	Water Requirement (m^3/hr)
1	Cooling water	**80000**
a	*Condensers*	*76703*
b	*Auxiliary cooling water system*	*3297*
2	Boiler Make up water	**22**
3	Water required for Ash Handling	**10**
4	Potable water requirement	**4**
5	Washing	**88**
a	*Turbine House surface washing*	*2*
b	*Coal storage washing*	*10*
c	Washing water for travelling screens	70
d	Road green area washing	3
e	UF back wash water	3
6	Water Sprinkling	**9**
a	*Coal Storage sprinkling*	*3*
b	*Ash field sprinkling*	*6*
7	*Internal Combustion*	***10***
8	*Acid and Alkali discharge water*	***1***
	Total Water Requirement	**80144**
	Recycled water (UF Back wash water recovery + activated carbon filter backwash water recovery)	4
	Total Fresh Water Requirement	**80140**

Source: OPDL-2

The water balance for the proposed plant is presented in *Figure 5-1.*

Figure 5-1: Water Balance for the proposed Project



5.2.3 Manpower

About 250-275 workers will be involved in the Operations and management (O&M) activities for the proposed plant. An O&M contractor with international work experience will be engaged for the first five years of the project and will involve influx of skilled labour. The international contractor will also provide training to local contractors who will take over the O&M activities after the completion of five years.

5.3 Fuel Requirement

The coal requirement for the project has been estimated as follows:

- Consumption, per hour 212 Tonnes/hour
- Consumption, per day 5088 Tonnes/day
- Consumption, per year 1484000 Tonnes/year

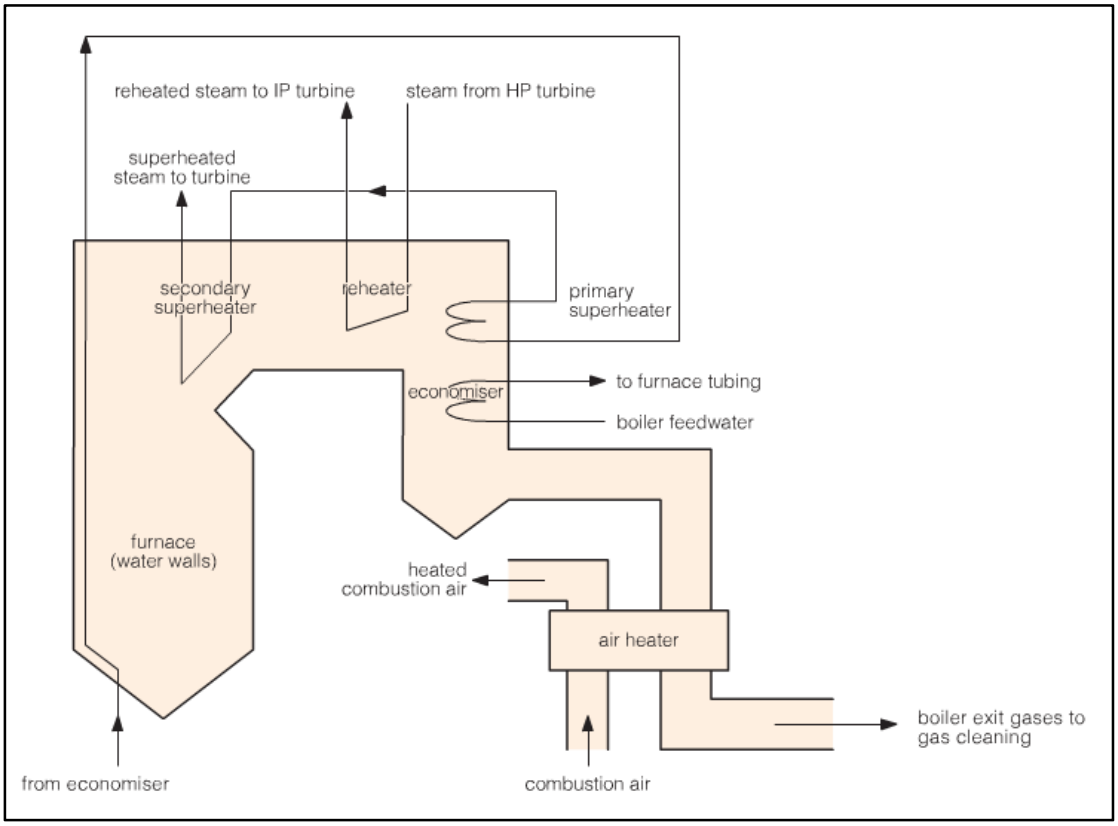
The coal for the proposed project will be sourced from Australia and Indonesia.

5.4 Technology Selection and Process Description

The proposed 635 MW Coal based power plant is based on Pulverised Coal (PC) combustion and a water-steam thermodynamic cycle. The coal from coal yard will be ground to a very fine powder by large metal spheres in the pulverized fuel mill and will be mixed with preheated air. The hot air-fuel mixture will then be forced at high pressure into the boiler where it rapidly ignites. The pressurized water will be heated beyond the critical point (22.1 MPa, 374˚C), above which water and steam are indistinguishable, to superheat temperatures in the ultra-supercritical once through two pass radiant type super critical boiler, equipped with a super heater steam system and a single reheat steam system.

The configuration of a typical once through ultra-supercritical boiler has been shown in simplified form in *Figure 5-2.*

Figure 5-2: Once Through Ultra-supercritical Boiler (Diagrammatic)



Source: Coal Combustion Technologies, IEA Clean Coal Centre, 2007

The steam will then be piped to the high-pressure turbine, the first of a three-stage turbine process. The steam will be exhausted from the High Pressure (HP) turbine, and reduced in both pressure and temperature. The reheated steam will then be passed to the Intermediate Pressure (IP) turbine, and from there passed directly to the Low Pressure (LP) turbine set. The steam exhaust from the LP-turbine part will be cooled down in a condenser by means of cooling water. The absorbed heat in the cooling water will be released to the Meghna River by means of a once through cooling water system.

The three turbine sets will be connected to three-phase electrical generators which will generate an intermediate level voltage. This is stepped up by the unit transformer to a voltage suitable for transmission (typically 250-500 kV) and is sent out onto the three-phase transmission system. Exhaust gas from the boiler is drawn by the induced draft fan through an electrostatic precipitator and is then vented through the chimney stack.

5.5 Description of Major Systems

5.5.1 Fuel Handling and Storage System

5.5.1.1 Coal Requirement and Specifications, Systems

The coal requirement for the project has been estimated to be 1484000 Tonnes/year.
The coal for the proposed project will be sourced from Australia and Indonesia.

The coal will be transported to the site in barges. The unloading facility will comprise of barge unloaders. The wharf will be provided with 6 shore cranes of 25tonne capacity each fitted with 8 tonne grabs. The facility will be equipped to have berthing and unloading of 5 vessels at any one time and 1 crane under preventative care and maintenance. One floating barge crane of 25 tonne capacity fitted with an 8 ton grab will be provided on standby for emergency and rescue situations.

The coal yard will be provided with a run off pit with drains around the coal yard. During monsoon, the rain water from the coal pile will be collected in drains and led to the coal pile run off pit. The run off pit will be equipped to separate out the coal particles from the runoff and this coal will be dumped in coal yard.

5.5.2 Fuel Oil Systems

The fuel oil handling and storage system will include unloading, storage and transfer of fuels to the oil tanks. Light diesel oil (LDO) will be used for the cold start of boiler load up to 7.5 % Boiler Maximum Continuous Rating (BMCR) and for auxiliary steam boiler. Heavy fuel oil (HFO) will be used for start-up of the boiler and during low load up to 35% BMCR. HFO will also be used for flame stabilization during low load.

5.5.3 Boiler

The proposed plant will comprise of a opposed wall fired Benson once through two pass radiant-type super critical boiler with a super heater steam system and a single reheat steam system and will be able to operate in sliding pressure mode.

5.5.3.1 Air – Flue Gas System

The air intake will be as per the ambient design condition (i.e. Temperature – 7 to 42 ˚C, Relative Humidity – 40-70%) and pressure of 1013 mbar. The flue gas inlet temperature to the Electro Static Precipitator will be 120˚C. Two forced draft (FD) fans will be provided to supply secondary air to the furnace to assist in combustion.

5.5.3.2 Combustion System

The system will be equipped with coal mills and coal silos, so that the boiler can operate at full load, BMCR. Each coal silo will have a storage capacity for 12 hours operation at BMCR.
The coal silo will have a normal outlet to the coal feeder and an emergency outlet to make it possible to empty the silo down on floor level in trucks in case of error to the silo system. The mills will be equipped with rotating classifiers and meet the design coal specifications. The boiler will be equipped with low NOx burners to reduce primary NOx.

5.5.4 Steam Turbine Unit

The steam turbine will receive steam from the boiler unit and will run at a speed of 3000 revolutions per minute (RPM). The turbine will be directly coupled to a synchronous generator to generate power. The steam turbine will be provided with necessary number of regenerative extraction/bleed points. After expansion in the HP turbine, part of the HP exhaust will be taken to the HP heater for feed water pre-heating and remaining part will be directed to the reheater for reheating and then to IP and LP sections of the turbine for further expansion.

5.5.5 Cooling Water Systems

The cooling water system provides the water for condenser. The main cooling water system for the proposed plant is a once through cycle (OTC). The inlet water will be drawn from Meghna River. A tapping from the main cooling water system inlet part will provide auxiliary cooling water and the heated auxiliary cooling water will be discharged back to the Meghna River Waste disposal system from the coarse bar screen.

Both the inlet and the outlet channel will be protected against flooding by having a dyke wall at both sides integrated in the channel side wall and at the dyke crossings.

5.5.6 Electrical and I&C (Instrumentation and Control) Systems

The steam turbine generator will be rated to deliver 635 MW net powers, with 0.8 lagging and 0.95 led Power Factor and 50 Hz frequency at the plants delivery point. The generator will be connected to the 400 KV switchyard through a Step-up transformer. The power will be evacuated from the 400 KV Switchyard through line feeders. The start-up power will be normally drawn from the grid (proposed 400 KV lines) through station transformer and Diesel Generator (DG) sets shall be provided for the black start of the plant. The size of the DG sets will be decided based on the power required for starting the plant.

The auxiliary power supply will be through 11kV and 400V lines and two (2) transformer units will be provided. The power supply for unit transformers will be tapped from the main run of the isolated phase bus duct.

5.6 Material Balance

5.6.1 Heat Balance

The proposed project is based on combustion of pulverised coal with calorific value of 26050 kj/kg. The emissions from coal combustion have been considered based on the coal firing rate at 100 % Boiler Maximum Continuous Rating of 212,000 kg/hr. Heat Balance for 100% load has been depicted in Figure Below.

5.6.2 Mass Balance

The thermal power generation will involve conversion of chemical energy into electrical energy with intermediary conversions into heat and mechanical energy. The broad process can be presented through the following equation:

$$Coal + Oxygen(Air) \rightarrow Products\ of\ combustion$$

The material balance for the two critical parameters, Sulphur and Ash has been presented in the subsequent section.

Sulphur

The coal for the proposed power plant will be imported from Australia and Indonesia. The coal consumption for the project has been estimated to be 212,000 kg/hr and the design coal will have a sulphur content of about 0.6 %.

$$S + O_2 \rightarrow SO_2$$

1272 1272 2544 (Values *in kg/hr*)

The sulphur dioxide generated will be emitted from the stack, details of which have been presented in section 9.5.4 of ESIA Report.

Ash

The coal consumption per day has been estimated as 5088 tonnes/day. The Ash content of the design coal will be about 9 % and will result in generation of fly ash and bottom ash during combustion. It is estimated that about 90 % of the ash will come out as fly ash and 10 % will form bottom ash. The details are presented below:

$$Ash\ Content\ in\ Coal \rightarrow Fly\ Ash + Bottom\ Ash$$

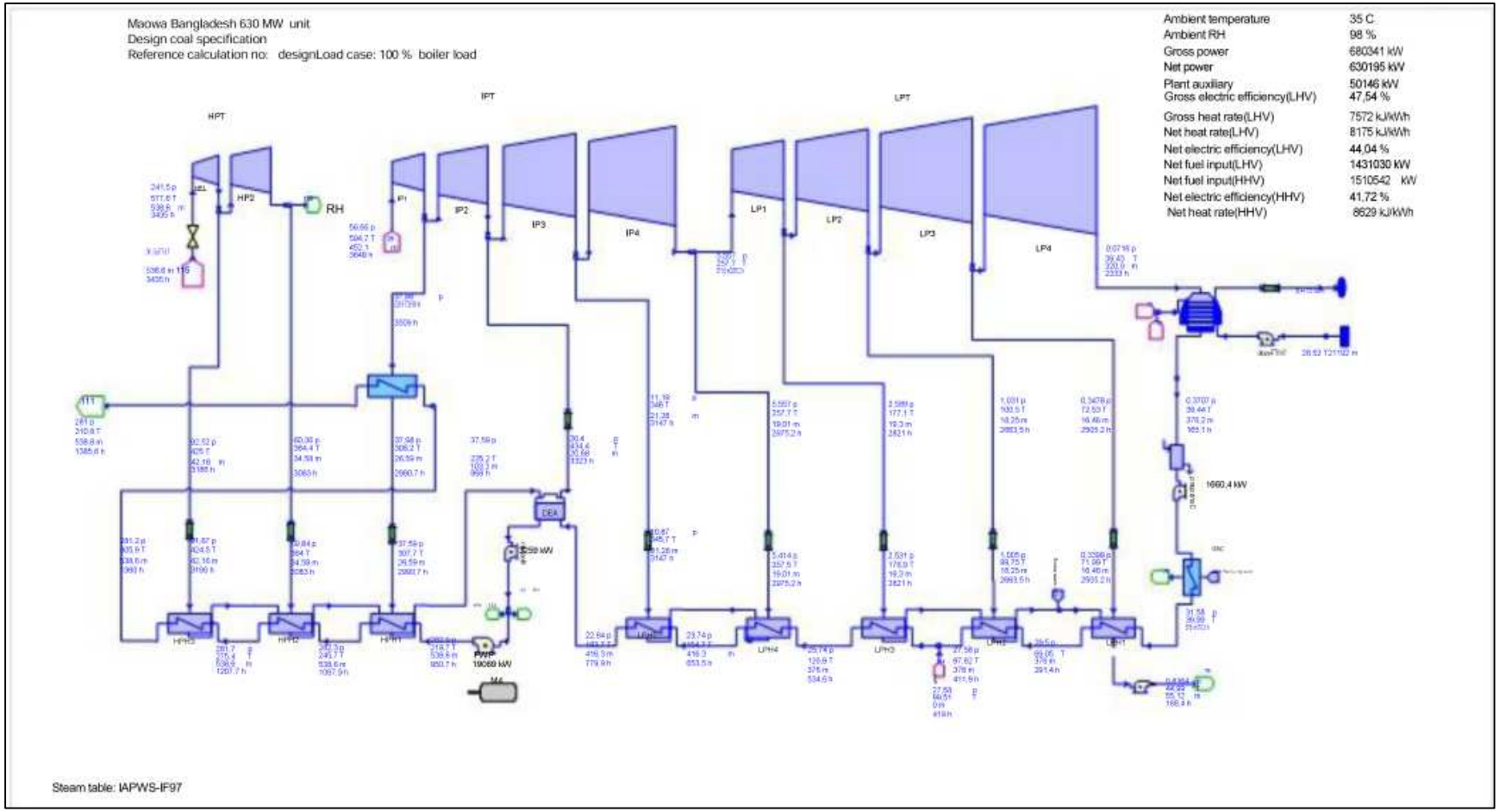
457.92 412.12 45.79 *(Values in tonnes/day)*

It has been estimated that approximately 412.12 MT/day of flyash will be produced by the proposed Power Plant which will be utilised by the cement plants situated in vicinity of the

proposed project site. A slag type wet bottom boiler will be installed in the proposed plant to manage bottom ash.

Water Balance for the proposed project has been presented in the section 5.2.2 of the report.

Figure 5-3: Heat Balance for 100% load



5.7 Pollution Control Measures (Units & Devices)

5.7.1 Air emission control system

5.7.1.1 Flue gas cleaning systems

Adequate flue gas cleanings systems will be installed so that the emissions are well below the allowable limited as given by Schedule-11, Standards for Gaseous Emission from Industries or Projects of the ECR'97, Schedule-12, Standards for Sector-wise Industrial Effluent or Emission section E, of the ECR'97 and International Finance Corporation's Environmental, Health and safety Guidelines for Thermal Power Plants.

Electrostatic Precipitator (ESP):

An electrostatic precipitator (ESP) will be installed to effectively remove the small particulate matter from the exhaust flue gas from the boiler and achieve high collection efficiencies (≥ 99.67%). The ESP sized for Particulate matter PM down to 50 mg/Nm3 for compliance with IFC Guidelines. The ESP will be located after the boiler in the boiler axis between the air heater and ID fans. The ESP will have a number of flue gas paths and fields with gas tight housing. The ESP shall be capable of meeting the maximum particular emission requirement even with soot blowing in operation. The fly ash is collected in hoppers below the ESP and conveyed pneumatically further on to the fly ash storage.

The nitrogen oxides will be controlled through installation of low NOx burner and through other techniques such as over fire air. A controlled portion of total combustion air flow, typically 10-20 %, will be directed through over fire ports located above the highest elevation of burner. The removal of air flow from burners will result in a fuel rich primary combustion zone to limit the NOx formation. In case, the NOx emission limit is not met by means of primary measures, installation of a Selective Catalytic Reduction (SCR) high dust De-NOx plant will be considered. Provision of space for Flue Gas Desulfurization system (FGD) has been kept in the plant area. If coal having more than 0.9% is imported, FGD will be installed and operated.

Stack Height: In compliance with the requirements ECR'97 Schedule-11, the plant will have a stack with a height of more than 275 m, with facilities for online monitoring of stack emissions.

Other methods: To control emission of fugitive dust within and around the coal handling plant and coal stockyard, dust suppression and extraction systems will be installed. Bottom Ash Handling System and Fly Ash Handling System will be provided with full enclosure to prevent release of any dust. Foggy nozzles will be provided in the coal yard for control of fugitive dust emissions. The chimney will also be provided with a Continuous Emission Monitoring System (CEMS).

5.7.2 Noise control

The major noise generating sources include turbines, turbo-generators, compressors, pumps, fans, coal handling plant. The equipment will be designed to control the noise level below 90 dB. All the DG sets will have acoustic enclosures limiting the noise to a maximum of 75 dB at one meters

distance. Personnel protective equipment like ear plug/ear muffler will be provided to workers engaged in high noise areas. The buffer area around the plant, boundary wall around the project will further dampen the noise level and minimise the impact on the nearby community.

5.7.3 Effluent treatment system

A central effluent treatment plant with the facilitation of Central Monitoring Basin (CMB) has been planned to collect, treat and dispose all the plant effluents. The liquid effluent shall be collected and treated / recycled generally as per following design philosophy.

- A portion of CW blow down water shall be used for dust suppression system of coal stockyard and balance shall be diverted to Central Monitoring Basin.
- Ash water system shall be generally operating in re-circulation mode; blow down if any from Ash water system shall be led to the CMB.
- Other plant drains/ effluent shall be collected and pumped to central monitoring basin.
- Regeneration waste of Demineralization Plant, condensate polishing plant and boiler blow down water shall be pumped to the CMB.
- Water from plant service water system and dust suppression system shall be collected from the plant drains and will be allowed to settle for removal of suspended impurities. The treated water will be pumped to the CMB.
- Drains from coal stockyard will be drained to a set of coal settling pond for removal of coal particles
- All the plant liquid effluents shall be mixed in CMB and quality of the effluent shall be measured and monitored. Through a set of water effluent disposal pumps and piping, the same shall be disposed of from central monitoring basins up to the final disposal point
- Final disposal will be made maintaining DoE's standard for effluent quality.

5.7.4 Ash Handling and Management System

The major waste stream during the plant operation comprises of fly ash and bottom ash. Two types of ash will be produced from coal combustion: i) bottom ash ii) fly ash. The ash handling system has been presented in Figure 5-4.

5.7.4.1 Fly Ash Handling System

Pneumatic conveying system (either vacuum system or pressure system) will be employed for conveying of fly ash from the electrostatic precipitator hoppers in dry form. Dry ash will be collected and transported in dry form to storage silo for utilization. The fly ash silos shall minimum have a net capacity of 72 hours production. The capacity will be split into two silos for redundancy. The silos will have two dry ash unloading spouts and two humidification systems with all accessories.

5.7.4.2 Bottom Ash Handling and Storage

A slag type wet bottom boiler will be provided for the proposed plant. The bottom ash will be kept in a molten state in the boiler and will be collected in the ash hopper which contains quenching water. When the molten slag comes in contact with the quenching water, it fractures instantly, crystallizes, and forms pellets. The ash pellets will be then stored in an HDPE lined ash pond. The dry bottom ash silo or container system shall minimum have a net capacity of 72 hours production.

5.7.4.3 Ash Utilisation

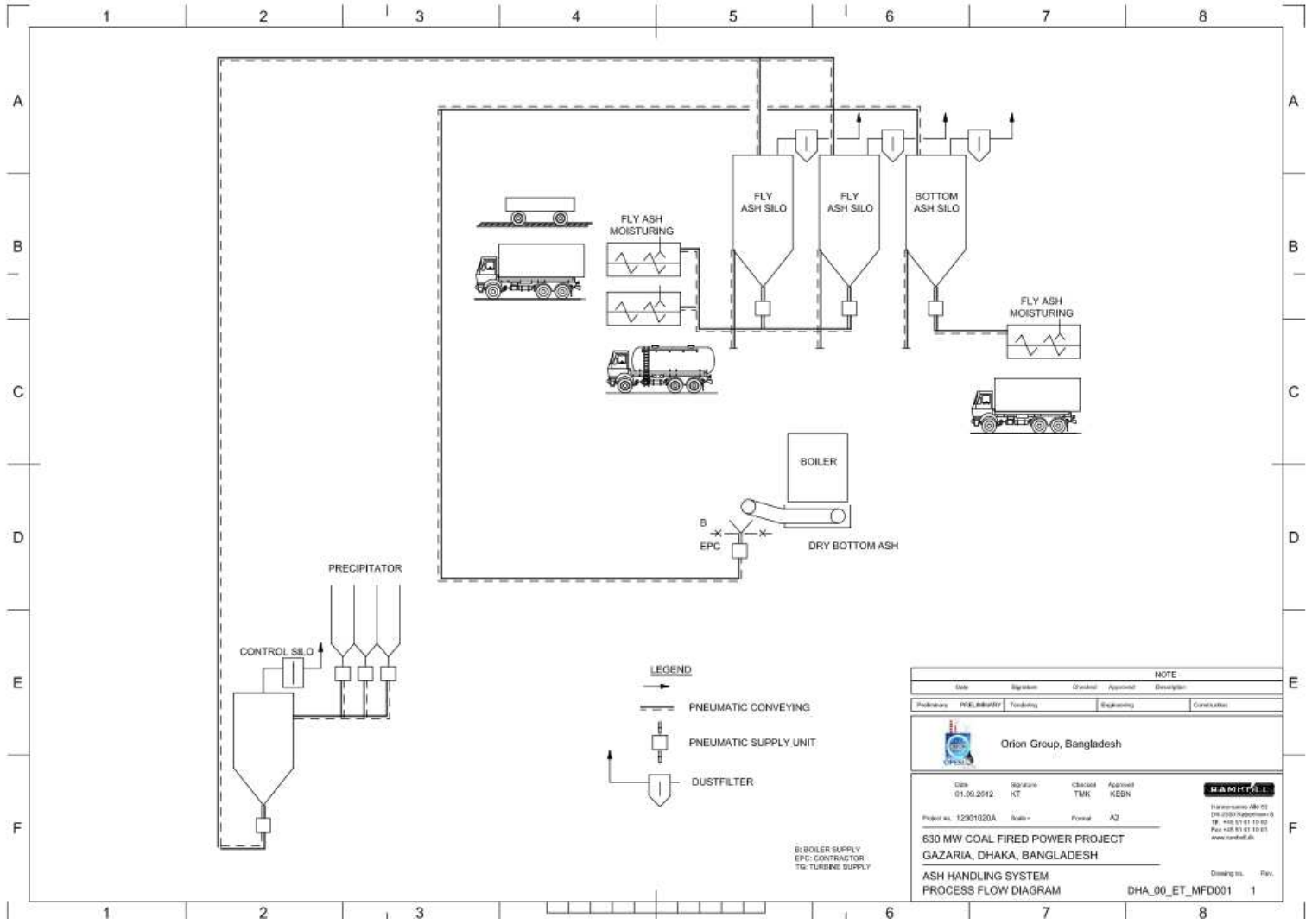
The dry ash is taken in dry form to storage silo near plant boundary for utilization. There are four cement plants located in the vicinity of the proposed plant and it is planned to tie up with the cement plants for sale of fly ash. 100 % utilisation of fly ash has been considered. The ash will be loaded to trucks through gravity flow for transport of fly ash to cement plants in the vicinity of the proposed power plant. . Purging with hot air will be done for dry dust free environment. In case the cement plant is located beyond 5-7 km of the plant boundary; the fly ash will be transported in covered barges. The ash will be loaded to the barge using an inclined chute with hot air.

The options for utilisation of residue ash such as use in brick manufacturing, clinker industries, cement industries, compaction purposes are also being explored. At initial stage, the generated ash will be used in land development within the project area. However, ash dyke has been planned in case of non-utilization of ash.

5.7.5 Other waste streams

The hazardous solid waste in the form of waste oil, spent ion exchange material and water pre-treatment clarifier sludge will be generated from the power plant. The waste oil will be collected in Mild Steel (MS) drums and stored on paved platforms with proper labelling. The waste will be sold to DoE approved vendors. The sludge will be dried and sent for land-filling. Spent Ion exchange material will also be sent for land-filling.

Figure 5-4: Ash Handling System



6. Analysis of Alternatives

IFC Performance Standards require that the Environmental and Social Impact Assessment shall undertake examination of alternatives, as appropriate including evaluation of project location alternatives, alternative project designs, alternate resource utilisation, alternate performance levels and alternative waste disposal options. This section compares no project scenario, reasonable alternatives sites, alternative raw materials and alternative process technology.

6.1 No Project Scenario

Bangladesh has an anticipated power requirement of 9,268 MW[3] for the year 2014 as compared to 8,439 MW for the previous year. Presently, the power demand growth rate is 10%, but it has been expected to be increase at a greater rate in the upcoming years. The power sector in the country comprises of 3 segments viz.

- Public sector – It comprises of BPDB, APSCL, EGCB, RPCL and NWPGCL; and
- Private sector – It is constituted by Independent Power Producers (IPP)/Supporting IPP, Rental power plants and Rural Electrification Board (REB).

Power Ministry's official statistics show the power generation capacity at the beginning of 2014 stands at 10,264 MW of which 5,962 MW (58 percent) belongs to the public sector while the private sector generates 4,302 MW (42 percent) including 500 MW import from India.

The gap between installed capacity and maximum generation of electricity in Bangladesh is increasing over the years, creating pressure on supply of electricity. The peak power demand and generation figures (Refer *Table 6-1*) indicate an alarming increase of 38.05% in power deficit. Electricity generation is not reliable as well as the peak demands are also not met. Moreover, power price is increasing with the increments of government subsidy.

Table 6-1 : Comparison between Peak Demand and Peak Generation

Parameter	FY 2011-12	FY 2012-13	% Change in parameter
Peak Demand (MW)	7518	8439	11.05
Peak Generation (MW)	6066	6434	6.07
Deficit (MW)	1452	2005	38.05

Source: BPDB Annual Report 2012-13

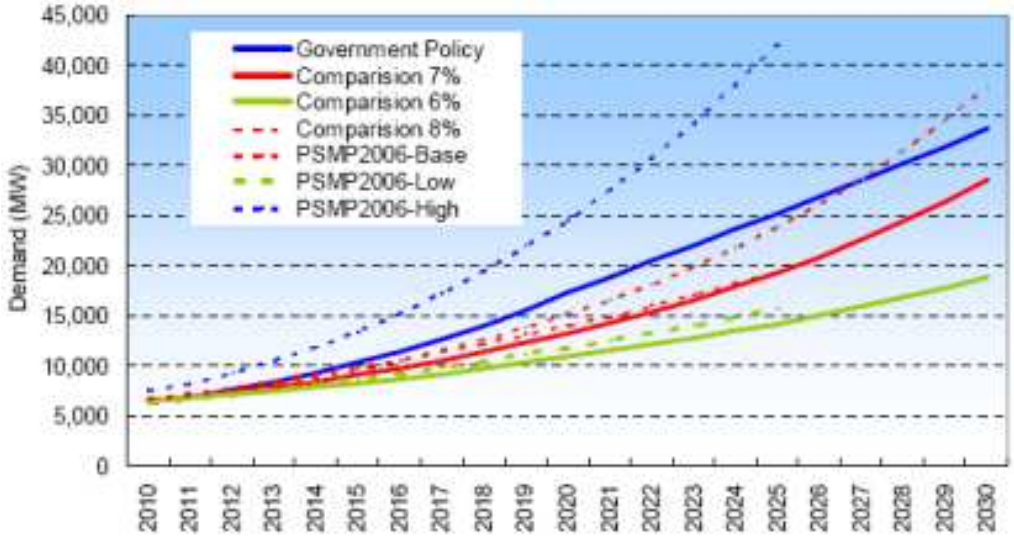
As per Power Division's (subsidiary of Ministry of Power, Energy and Mineral Resources, Government of Bangladesh) estimates, 62% of the country's population has access to electricity and the per capita generation is 321 kWh.[4] Government of Bangladesh has assigned top priority to the development of power sector realizing its importance in economy, industrial and social development of the country. In this regard the government has set the vision to provide access to affordable and

[3] *BPDB Power Demand Forecast : http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=12&Itemid=126*

[4] *http://www.powerdivision.gov.bd/user/brec1/30/1*

reliable electricity to all by the year 2021. The government is further focusing into its vision targeting the upcoming years up to 2030 and prepared the Power System Master Plan (PSMP) in 2010. The Plan formulated by the Ministry has anticipated a peak power demand of 24,000 MW by 2021 and 34,000 MW by 2030. Power supply targets of 24,000 MW and 39,000 MW have been envisaged under the Plan in the respective years in order to meet the rising power requirements.

Figure 6-1: Power Sector Master Plan



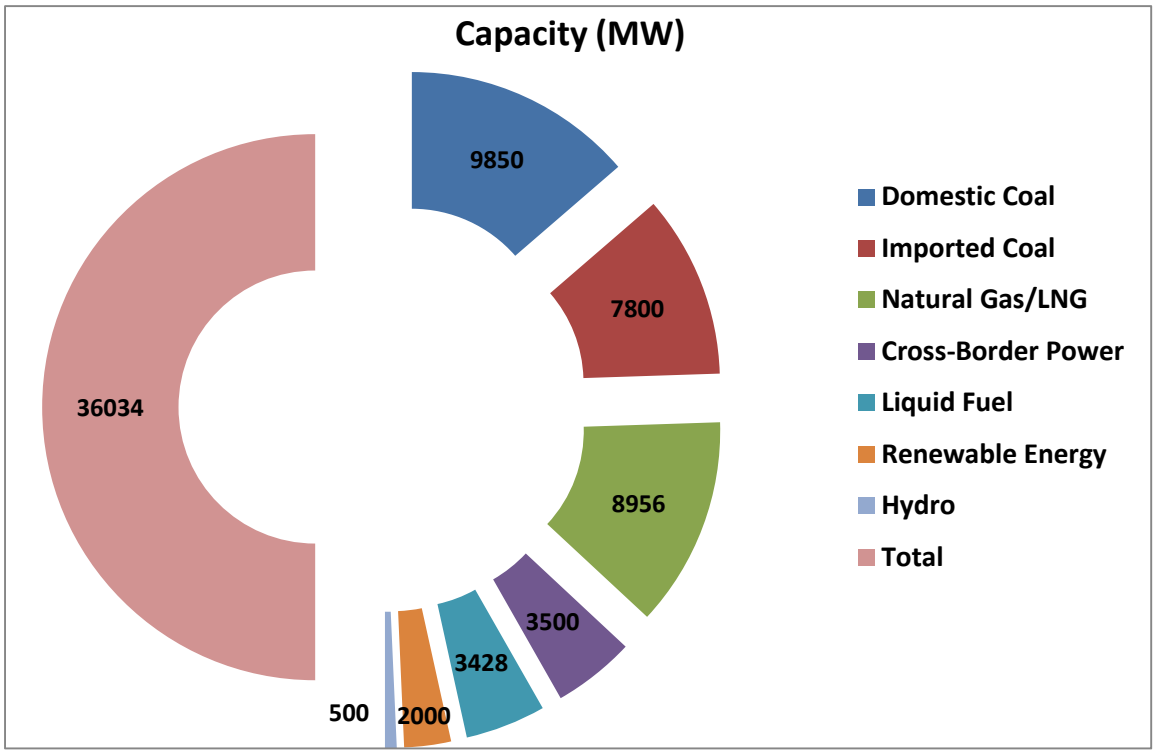
Source: Power Sector Master Plan, 2010 (MoPMER, Bangladesh)

The government has designed a strategy to overcome the crisis and at the same time meet the ever increasing demands for power. It launched short, medium and long term programs to increase power supply based on introduction of fuel mix (gas, coal ,liquid fuel, nuclear energy and renewable), demand side management, energy efficiency and conservation. After assessing the latent demands, the government has revised upward its targets for increasing power generation. It now plans to generate 9,600 MW by 2013 and around 15,000 MW by 2016.

Between 2010 and 2016 the Bangladesh Government has plans to generate 14,773 MW of power. Among these, 6204 MW which is 42% of the total target will be from public sector. 8569 MW which is 58% of the total target will be from the private sector.

Further to add to the concerns, the country has five power plants aged over 40 years, 11 plants within 31 to 40 years, 23 plants within 21 to 30 years, and 19 plants within 11 to 20 years. As the maximum acceptable lifetime of any power plant is 20 years, frequent tripping or technical glitches in power plants on a daily basis is hampering around 1,500 MW of electricity generation.

Figure 6-2: New Power Generation Target by 2030



Source: Power Division, Ministry of Power, Energy and Mineral Resources (http://www.powerdivision.gov.bd/user/brec/104/110)

The government policies and plans are focussed at increasing the grid supply coverage in the country, which is currently less than 40%. The proposed project is part of the overall effort of the government to mitigate the energy crisis. A no project scenario is not as per the intentions of the governments' plan. An alternative without the project is undesirable, as the worsening power shortage would constrain economic growth and prevent alleviation of poverty. It will also lead to an increase in burden on the depleting natural gas reserves of the country on which it heavily relies for power generation.

6.2 Alternative site selection

The factors that broadly determine power plant location include ability to transport coal to the site, availability of water, land and transmission to grid. Environmental and social factors of concern are proximity to sensitive ecological receptors, relocation of people, change of land use, influx of migrant workers etc.

Two sites (Refer *Table 6-2* and *Figure 6-3*) were considered as part of project conception, the locations considered were:

Table 6-2: Proposed project locations

Site No.	Location	Geographical Coordinates	
		Latitude	Longitude
I	Near **Mawa,** 5-6 km away from Dhaka – Mawa road , along the bank of Padma River	23°29'43.07"N	90°11'17.05"E
II	Approximately 2km from **Kajjar Gao**, along the bank of Meghna River	23°34'41.66"N	90°34'12.20"E

Source: OPDL-2

Figure 6-3 : Proposed locations for the project

The site selection criteria employed for assessing the two sites considered for the project are summarised as *Table 6-3*:

Table 6-3: Comparative Analysis of the Site Options

SN	Criteria	Site –I	Site- II	Comparative analysis
1.	**Location**	Located on the northern bank of the Padma River. The site is approximately 125 nautical miles upriver from the possible deep sea anchorage point at Chittagong.	Located near Kajjar Gao on an island along the western bank of Meghna River. The site is at an approximate distance of 200 nautical miles from the deep sea anchorage point at Chittagong.	Both locations are similar in terms of location for power Plant.
2.	**Topography**	The topography of the area is flat	The topography is flat with	Topography is similar

SN	Criteria	Site –I	Site- II	Comparative analysis
	and land use	with the presence of scattered settlements. The land would require a filling up of low lying areas before construction.	shrimp farming being the main activity. The land is low lying and will require filling up.	with no distinct advantage
3.	**Need for Resettlement**	There are scattered settlements on the proposed site. The settlement is denser near the bank of river Padma.	There are no houses on the proposed project site.	Site – II is better since it does not involve any physical displacement.
4.	**Connectivity /access**	The project is located around 5-6km away from the Dhaka-Mawa road and now connected with a narrow village road, so, the road communication should have to be developed for the project by the project authority. Coal shall be transported by river using barges.	The site is situated on an island hence river navigation is the only mode of transportation. Coal shall be transported by river using barges.	The Site - I am better connected and will require lesser infrastructure for access.
5.	**Fly Ash transportation**	No industrial units are located near the proposed site.	Cement manufacturing plants are located near the proposed project site.	Site II is a better option owing to its proximity to cement manufacturing plants. The fly ash generated during power plant operation can be conveniently and cheaply transported to these plants which can be subsequently used as raw material for cement production.

Source: Assessment of Locations, AECOM

Conclusion: On the basis of the six aforementioned factors, Site – II is a better alternative since it does not involve any physical displacement of people and has cement manufacturing plants situated in the vicinity which accounts for convenient transportation of fly ash.

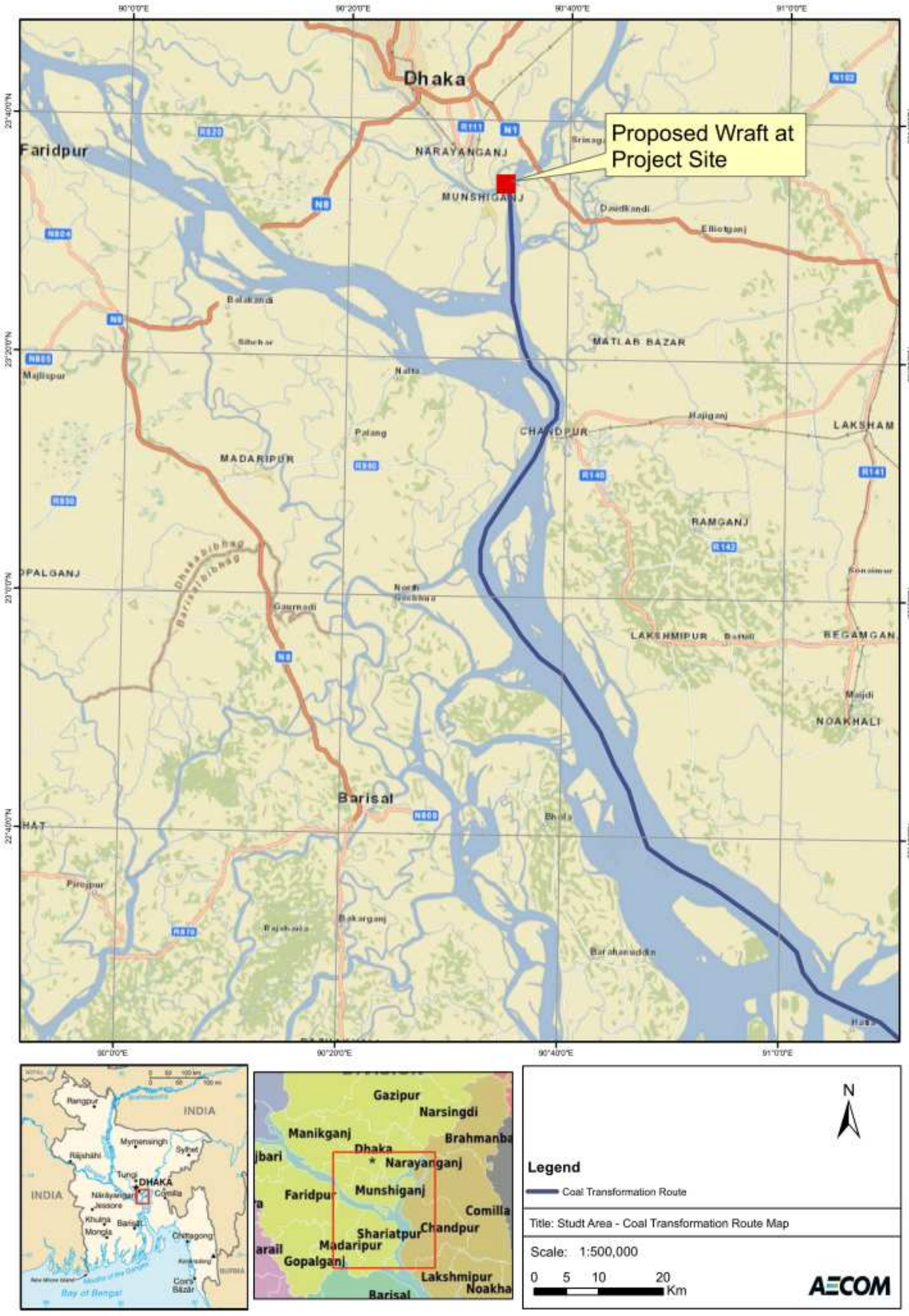
Hence, Site – II has been finalised for setting up the proposed power project. The responsibility of road development and associated infrastructure on the site lies with OPDL-2.

6.3 Transportation of Coal

Availability of coal in Bangladesh is limited and the requirements for power plants are mostly met through imported coal from South East Asian countries or from Australia. Imported coal is transported through water navigation, which requires proximity to navigable rivers or coastal area, therefore proximity to navigability of river was an essential factor in site selection. The vessels (mother vessel) that will be used will be Panamax type bulk carriers that will require a minimum draft of 12.8m as a per desktop study undertaken for the logistics of Coal to the proposed site. The Meghna River is in category class I with a minimum water depth of 3.66m and minimum vertical clearance of 18.30m and horizontal clearance of 76.22m.

The coal will be transported to the site in barges. The unloading facility will comprise of barge unloaders. The wharf will be provided with 6 shore cranes of 25tonne capacity each fitted with 8 tonne grabs. Delivery of coal to the plant will be undertaken through Mother Vessels which will arrive directly from Chittagong which is situated at a distance of 240km approximately in south east direction from the site and sail on the incoming tide directly to the plant wharf to fully discharge the cargo. The coal will be transported via Chandpur to the proposed site. This completely eliminates the need for any anchorage or transfer to Lighters. Direct transfer to site will also prevent spillage of coal into sea during transfer to lighter. The handling of the coal from the barges will be performed by barge loaders and transported to the storage area by conveyor belts. Figure 6-4 shows the route that will be adopted for transportation of coal from Chittagong to the plant.

Figure 6-4 : Route of Transportation of Coal

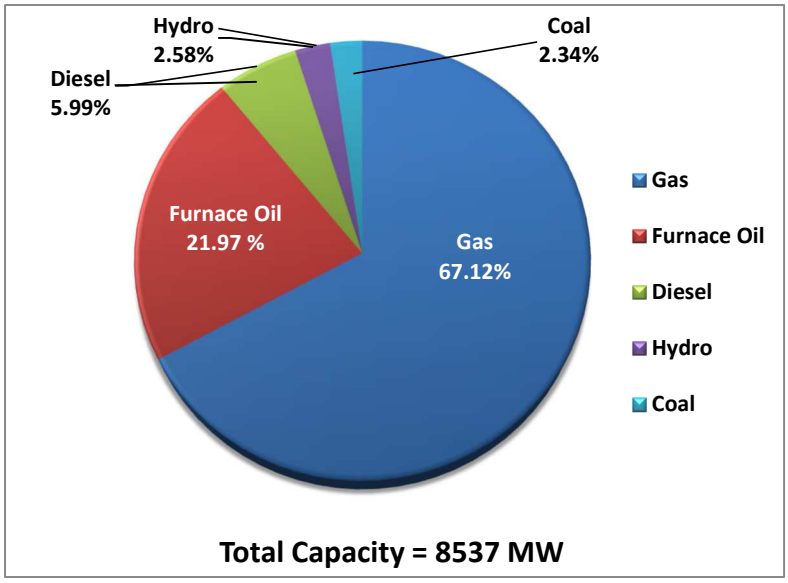


6.4 Alternative fuels

Coal is still the most cost-effective fuel for generating electricity. For large scale energy production, one of the conventional modes of power generation has to be adopted, even though coal has higher pollution potential than some of the other fuel such as natural gas, oil and nuclear. Renewable energy is location specific and not in a position to supply large power on continuous basis to act as a base load plants.

Bangladesh heavily relies on natural gas for power generation. In the year 2013 (***Figure 6-5***), natural gas fired power plants contributed the largest share of 5730 MW (67.12%) to the total installed capacity whereas furnace oil was the second largest contributor with 1876 MW (21.97%). Diesel fired power plants (511 MW) accounted for 5.99% of the capacity whereas hydro (220 MW) and coal power plants (200 MW) contributed 2.58% and 2.34% respectively.

Figure 6-5 : Power generation by fuel type



Source: BPDB Annual Report 2012-13

The availability of gas in Bangladesh is on decline. Non-availability and un-affordability of fuel such as natural gas or oil is an important factor to consider in Bangladesh. To transport natural gas, large investment in infrastructure is also required. Also, there is a significant demand existing for gas from other industrial consumers and transportation making it a commercially unviable option furthermore.

This would leave two other real alternatives which are coal and nuclear energy. Between coal and nuclear, coal is the preferred choice given its shorter gestation period, lower costs, and relative safety. Use of Nuclear technology in Bangladesh for power generation at large scale is yet to emerge and there are strategic and fuel availability issues that confronts this sector.

6.5 Alternative Boiler Technologies

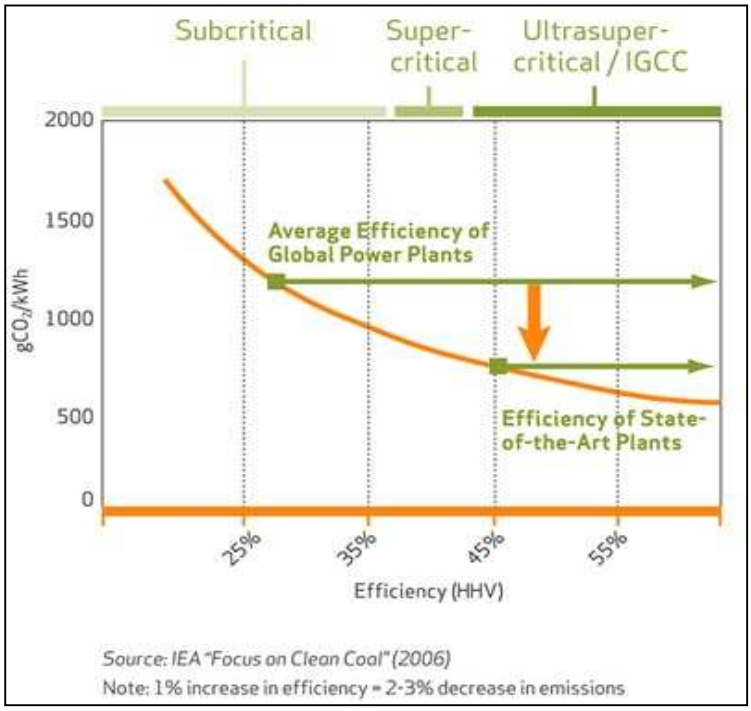
The technology options for large pulverized coal-fired power plants are subcritical, super-critical and ultra-super critical. Ultra-supercritical plants operate at steam pressure above 22.1 megapascals

(about 3,200 pounds per square inch) and use once-through boilers. In the ultra-supercritical stage, water becomes gas. Subcritical plants operate at steam pressure below 19 megapascals and use drum-type boilers. In the subcritical stage, the steam is a mix of liquid and gas. The ultra-super critical plants are a class above ultra-supercritical and operate at ~2-3% higher efficiency than ultra-supercritical ones. It operates with steam pressure and temperature range of 25.4 MPa g and 571ºC.

Currently, the ultra-supercritical technology is fast becoming standard practice in the power industry for large coal-fired power plants for its efficiencies of 42% or higher, compared with the subcritical technology efficiency of 35–38%. Higher efficiency means better utilization of coal, hence cutting down emissions. (Refer ***Figure 6-6)*** The lifecycle costs of ultra-supercritical coal-fired power plants are lower than those of subcritical plants. Current designs of ultra-supercritical plants have installation costs that are only 3-5% higher than those of subcritical plants. Fuel costs are considerably lower with an increased efficiency and operating costs are either lower or the same as compared to subcritical plants. More than 400 ultra-supercritical plants are operating in the US, Europe, Russia and Japan.

The concerns of carbon foot print demands further increase in efficiency whist burning coal and Ultra Super Critical (USC) technology offers even higher efficiency and therefore lower emission than any other technology class. USC based power plants are constructed in recent times in Europe, USA and Japan, based on high quality coal available in the western countries, however, no such units are being built with low quality coal as yet. The affordable electricity is the key for development in the developing economies like Bangladesh. The high capital cost resulting in unaffordable tariff to the customer, reliability issues of this technology on available coal and lack of indigenization are proving to be the bottleneck to make this a viable option right now for adoption.

Figure 6-6 : Emission reduction with increase in efficiency



Source: http://www.worldcoal.org/coal-the-environment/coal-use-the-environment/improving-efficiencies/

Ultra-supercritical plants are relatively more attractive in environmental terms compared to subcritical, as their emissions per unit of electricity generated are lower than those of subcritical plants. A 1% increase in efficiency reduces specific emissions such as carbon dioxide, nitrogen oxides, sulphur dioxide, and particulates by 2.5-3.0%.

Considering all the above factors into account for the Orion Power Unit-2 Dhaka Limited (OPDL-2) Project, a ultra-supercritical steam condition is adopted with rated super heater outlet steam pressure of 25.0 Mpa.g, rated super heater outlet steam temperature 580°C.

7. Land Cover/Land Use

Land use in Bangladesh is determined mainly by the monsoon climate and the seasonal flooding which affects the greater part of the country. These physical determinants are reinforced by high population pressure and increasingly, by alterations to the natural environment through flood protection, drainage and irrigation interventions.

7.1 Methodology Adopted

Based on the geographic coordinates of the Project area, the satellite imagery were geo-registered and geo-referenced with respect to ground control points from GPS. 2nd order polynomial transformation was used to achieve higher accuracy in geo-referencing.

Indian Remote Sensing (IRS) – LISS IV Multispectral Satellite imagery were processed in ERDAS Imagine for preparation of land use land cover using unsupervised classification technique for a study area of 10km around the project site. Major land use classes have been delineated as agriculture land, industrial land, settlements, water body and river. The digital classified map was verified for the accuracy assessment for major land-use classes present in the study area and land use land cover map has been finalized.

Table 7-1 and *Figure 7-1* present the land use pattern prevailing in the study area. According to it, 60% of the study area is under agriculture, 12% is occupied by settlements. Land Use map of the area is presented in *Figure 7-2*.

Table 7-1: Land Use Pattern of the Study Area

S.no	Land Use Category	Area in Sq.km	Area Covered (%)
1	Agriculture Land	242.67	60.66
2	Settlements	51.03	12.75
3	Water body	11.66	02.91
4	Rivers	87.07	21.76
5	Industrial Land	07.57	01.89
Total Area		**400.02**	**100.00**

Source: Land Use Map, AECOM

Figure 7-1: Existing Land Use Pattern of the Study Area

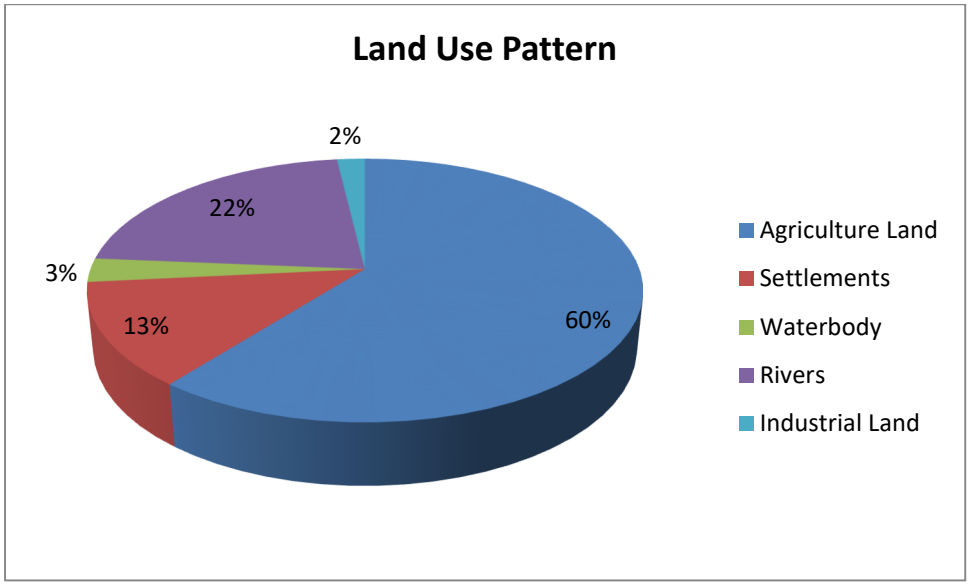

Land Use Pattern
2%
22%
3%
13%
60%
Agriculture Land
Settlements
Waterbody
Rivers
Industrial Land

Figure 7-2: Land use Map of the study area