2x350 MW SUPERCRITICAL COAL-FIRED POWER PLANT

ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT

DRAFT REPORT

深圳能源
SHENZHEN ENERGY

VOLTA RIVER AUTHORITY

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ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT

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Premier Resource Consulting	
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EXECUTIVE SUMMARY

- **The Scope, Purpose and Objectives of the Project**

Shenzhen Energy Group Co., Ltd. (SEC) in collaboration with Volta River Authority (VRA) intends developing a 2×350MW supercritical coal-fired power generating plant (including the affiliated coal handling terminal) to be situated along the coastline of Aboano in the Ekumfi District of the Central Region of Ghana.

The Shenzhen Energy Group Co., Ltd. was incorporated in 1991 in China and became listed on the Shenzhen Stock Exchange in 1993. Through the years SEC has developed its core business in power generation with environmentally friendly energy, gas business and related energy finance as subsidiary business both on the Domestic and International markets. Presently, SEC operates three coal-fired power plants and two additional supercritical power plants are in construction phase.

Volta River Authority (VRA) is solely owned by the Government of Ghana and was established in 1961 by the Volta River Development Act, Act 46 of the Republic of Ghana to generate and supply electricity for the country. Presently, VRA is the largest power generation company in Ghana combining hydro, thermal and solar plants to generate electricity for supply to the local and West Africa Regional markets. VRA has subsidiaries, which also create relevant strategic pattern supporting its leading operations, including Northern Electricity Distribution Company (NEDCo), Akosombo Hotels Limited, Volta Lake Transport Company and Kpong Farms Limited.

The purpose of the project is to develop primary power generating source providing the needed stability and security in baseload power generation capacity of the country and contributing to solving the serious local domestic power shortage experiences in Ghana and other West African countries. Furthermore, the project seeks to address the imminent power in-balance and supply deficit in the near future given the prevailing power demand growth.

The 2×350MW supercritical coal fired power project is developed aiming at providing electricity to serve mainly the southern area of Ghana and therefore providing a regional power plant.

The development of the coal-fired power plant is justified by the need for cheaper and reliable power generating source to secure and stabilize the base load generation capacity of Ghana and provide the needed stability for the development of renewable energy generation.

- **Legal and Regulatory Requirement**

In accordance with the Environmental Protection Agency Act 1994, Act 490 (Parts 1&II) and Environmental Assessment Regulations 1999, LI 1652, an Environmental and Social Impact Assessment is required prior to the development of the proposed project.

The environmental and social impact assessment would comply with National Environmental laws and Quality Guideline, other relevant Ghanaian legislations which are applicable to the project and relevant international agreements and conventions. The ESIA will conform to a number of international guidelines and standards including the IFC Performance Standards particularly the Environmental, Health and Safety Guidelines for Thermal Power Plant and would meet the requirement of the Equator Principle and the Green Credit Guidelines of the China Banking Regulation Commission.

- **Brief Project Description**

The project is conceived to develop a total capacity of 2000MW Supercritical Coal-Fired Power Plant with affiliated coal handling terminal, infrastructure, residential and outdoor area. The project planned in two phases would involve the development of 2x350MW Supercritical Coal-Fired Power plant in Phase 1. A second phase is also planned to develop two units 2x350MW or a 2x600MW Supercritical Coal-Fired Power Plant. The first phase of the project is planned to commence in December 2017 and be completed in 2020-2021.

The generating units would comprise of two power blocks each consisting of:

- A boiler based on supercritical pulverized coal technology;
- A steam turbine and generator unit with 350 MW rated output;
- A once through circulation cooling water system;
- Electro-static Precipitator for removal of dust in flue gas
- Seawater Flue Gas Desulfurization for removal of SOx in the flue gas
- Low NOx burners
- Selective Catalytic Reduction System

The power generating process would involve burning pulverized coal in a boiler (steam generator) to heat water to produce steam, which flows to drive the turbine and generator to produce electricity. The power produced would be evacuated through a 2x15 km 330kV transmission lines to the national power transmission line from Aboadze to Tema. Ash would be generated from burning coal in the form of fly ash and slag, which would be transported to the ash storage yard using trucks. The ash yard is initially considered for five-year ash storage.

Preliminarily, the principal source of coal for the project considers thermal coal imported from South Africa and shipped from Richards Bay in South Africa to the affiliated 70,000 DWT coal handling terminal of the power plant situated at Aboano in the Ekumfi District of Ghana. Another coal source imported to serve as back – up coal source for the project is Columbia.

The ancillary facilities to the power plant include:

- 330kV transmission lines
- Once through circulation cooling water system
- Wastewater treatment system
- Firefighting system
- Coal unloading, storage, conveying and pulverization system
- Ash storage yard
- Residential quarters
- Access road
- Coal handling terminal

The Coal Handling Terminal (CHT) is proposed for 70,000DWT coal carriers mainly from South Africa where the coal will be sourced from. The CHT will also have a Material Offloading Berth designed for 10,000DWT vessels with length of 174m. The coal unloading facilities are two grap type ship unloader each of capacity 1500 tons/hour, which transfer the coal onto belt conveyors for transportation to the transfer tower on land.

The project water sources are proposed to include desalinated seawater and fresh water from Essakyir Water Treatment Plant. The desalinated seawater would mainly be used for boiler make-up water and the fresh water from Essakyir Water Treatment Plant would be used for other water requirements of the power station, particularly service water system including industrial water system and portable water system.

The drainage water system is separately arranged and all kinds of wastewater would be reuse after treatment respectively.

The environmental protection measures of the project include:

a) Anti-seepage Measure comprising composite geo-membrane set on the surface of bottom and inside slope for the ash storage yard to prevent seepage from wet ash into the ground.
b) Buffer Area composed of 10m wide green belt set around the ash storage yard to reduce pollution of fly ash. The green belt can also improve

landscape view of the surroundings.

c) Ash received at the ash storage yard would be rolled in time involving watering on the surface of the ash body.
d) The ash storage facility would be monitoring twice a year in relation to the displacement and settlement set on top of the primary dam.
e) Sulphur Oxide Emission Control measures include adopting low Sulphur content fuel and seawater flue gas desulfurization (FGD).
f) Nitrogen Oxides Emission Control measures considered low NOx burners and selective catalytic reduction (SCR)
g) The project adopts electrostatic precipitators (ESP) as the principal particulate control technology
h) Five sets of Continuous Emission Monitoring System (CEMS) would be installed in stack and gas duct of desulfurization system.
i) Pulse fabric dust collectors would be adopted at the main fugitive dust points such as coal transfer tower, coal crusher house and bunker bay.
j) Fire Detection and Fire Fighting Control System arranged to realize automatic fire detection and alarm in the main building, desulfurization system, coal handling and wherever prone to fire in Auxiliary system buildings.

The main powerhouse is located and laid out to allow expansion conditions necessary to meet the overall planned capacity. The main power house is arranged near the sea and located in the evacuation area. The geographical conditions in the plant area are conducive.

The project, which is planned to commence in December 2017 and commission commercial operation in 2020/2021, is estimated to cost 1.5 billion US Dollars.

➢ **Project Alternatives**

The project design considered a number of alternative solutions and technologies to identify the best solution options and available technologies given the prevailing specific local conditions and circumstances. These alternatives include:

- Alternative power generation; particularly evaluating natural gas as the fuel source compared with coal, assessing the long term operational efficiency and viability, engineering, economics and environmental impact and implications as basis for future developmental consideration.
- Alternative boiler technologies comparing efficiencies and suitability given design parameters of sub-critical pulverized, super-critical pulverized and ultra-super critical pulverized coal-fired power plant.

Additionally, the evaluation also considered the pulverized coal (PC) type and the circulating fluidized bed (CFB) type boilers and finally biomas co-firing option.

- Flue Gas Desulfurization (FGD) Considerations comparing limestone gypsum FGD and seawater FGD
- Carbon Dioxide Emission Control considerations evaluating carbon capture and storage (CCS) Technology and its maturity for optimal adoption.
- Seawater cooling options considering advantages Cooling Tower System and Direct Circulating (Once Through) Cooling Seawater scheme.
- Coal storage facilities considering the two basic alternatives identified as the open yard storage system and the close yard storage system.
- Fuel type considerations also reviewed the coal quality types and diesel oil specifications.
- Site selection considerations reviewing Akwidaa and Ekumfi Aboano site situations in view of site suitability given development and operational requirements.

➢ **Brief Explanation of the Methods by which Information and Data Were Obtained**

There are two principal sources of information and data identified as primary and secondary sources of information and data. The sources of data determined the methods by which information and data were obtained for the study.

The methods of obtaining information and data from the primary sources include consultations and dialogue, which also involved focused group discussions and direct and inter-personal interviews. Additionally, primary information and data were obtained through field studies, technical and engineering investigations and chemical analytical assessment of environmental situation.

Consultations and dialogues commenced from project conception through the inception of project development from Pre-feasibility preparation through feasibility phases. The consultations continued through the scoping phase and subsequently through the preparation of the ESIA.

More than 20 stakeholder groupings including governmental agencies, the communities, the public, media and civil society organisations have been engaged in various consultation and dialogue mechanisms and have been informed appropriately of the potential development impact and implications of the 2X350 Supercritical Coal-fired Power Plant.

The stakeholder groupings include public stakeholders, which can be categorized into three levels namely National, District and Local level consultations. The identified stakeholders include EPA, Energy Commission, Ministry of Energy, GRIDCo, VRA, Forestry Commission (Wildlife Division), NGOs and Central Regional Coordinating Centre (Minister's Office), Ekumfi District Assembly and the Chiefs and people of the communities.

The methods of obtaining secondary information and data included desk research involving literature reviews, review of publications and guidelines and review of project studies documentation.

- **Brief on the Baseline Data**

The Project site is located within of Ekumfi Aboano Area and is proposed to cover an estimated area of 139 hectres. The project would influence areas including Ekumfi Aboano community, Ekumfi Kontankure Settlement, Ekumfi Estibeedu community, and Ekumfi Otuam community within the Ekumfi District Assembly area.

The area, being a part of the coast of Ghana, belongs to the tropical climate zone, which has two main seasons identified as the rainy season and the dry season. Ghana has high temperature all year round with a monthly average air temperature of 26^{0}C in the coastal region with an annual average relative humidity of 85%. The annual rainfall of Ghana is around 1200~1800mm for the south and southwestern part. The dominating wind direction is SW, the annual average wind speed is 2.5 m/s, the instantaneous maximum wind speed is 35 m/s. The annual average atmospheric pressure is 1012.1hPa.

The project site is situated within no fault zone, which is stable and suitable for the construction and development of power plant. The site can be considered as a section having advantage to seismic protection of buildings.

The groundwater is bedrock fissure water type replenished by surface water from rainfall. According to the site investigation and survey work, the average maximum water table is more than 20m.

The site is affected by three small watershed flood and the design peak flood flow at section of three watershed outlet once-in-100-year is 4.73m^3/s, 3.61m^3/s and 29.9m^3/s accordingly.

The reported air quality characteristics show SO_2 and NOx concentrations were largely lower than the Ghana EPA ambient air quality guidelines but with TSP and PM consuming the guideline by 26.19% and 76.06% respectively due possibly to the severe harmattan at the time of the measurements. Noise levels were considerably high and above the EPA guideline standards especially within the community settlements averaging 59 dBA to 63 dBA.

The biological environment depicts Maritime and the Coastal Scrub and Grassland vegetation zones. The zone has been extensively farmed and as a result has become highly degraded. Part of the area coincides with the Southern Marginal forest type. Remnants of the original vegetation of the area are found in isolated pockets of forest reserves or sacred grove. Generally, the wildlife of Southern Ghana and in the Central Region is very rich and diverse. Investigations had revealed that the abundance and diversity of wildlife species in the area has reduced drastically over the past two decade.

Marine Environment

Extensive study of beach seine catches of the central coastline of Ghana identified varieties of species in low abundance. There is no existing documented sea turtle data or information on sea turtle activities or threats specifically for the project area.

Landscape and Seascape Visual

The landscape and seascape visual characteristics generally reflect natural but exploited environment resulting from human activities. Presently, the characteristics of the landscape represents natural grassland vegetation zone that had been farmed extensively and become significantly degraded. The site, in particular, demonstrates existence of plant outgrowth on rocky surface and lying along the coastline. The overall aesthetic character therefore depicts natural environment which given the village setting has friendly and positive impact on the people.

At present, the seascape is represented by coastline with maritime vegetation intersperse with strand and mangrove vegetation occupying the foreshore. The shoreline also portrays high water mark with outcropped rocky beach stretching almost the length of the site.

Socio-economic Baseline

Ekumfi Srafa Aboano falls within the jurisdiction of the Ekumfi District Assembly. There are approximately 52,000 people inhabiting the Ekumfi District out of which 1900 of the District's population reside in Ekumfi Aboano (GSS, 2014). The population of Ekumfi Aboano is considered youthful because approximately 55.9 % of the population represent children. There two hundred and sixty (260) homes in Ekumfi Aboano with an average of 13 – 15 people per home (Ghana Statistical Service, 2014; Global Brigades, n.d.).

The primary livelihood activity of the five communities is fishing and farming. However, other livelihood activities include petty trading, charcoal production, food vending, operation of drinking spot, hairdressing and dressmaking are complementary economic activities, which the population engage in.

Historical, Cultural and Traditional Heritage

The Fantes constitute the dominant ethnic group in the Ekumfi District. There are notably varieties of historical resources, cultural and traditional heritage forming the conceptions, beliefs, reverence, obedience and faith of the people and contributing to their socio-cultural and economic well-being.

Key historical features include the common point demarcating the boundaries of the adjoining communities known as "Esiwodo"; the "Odaabiriadze" forest, which serves as a central point of prayer, libation and spiritual consultation for the settlers of the communities and especially during the Odwira (purification) festival; A stream referred to as "Nana Atsiribura" (Small River); and the sea and shoreline of the Aboano community.

These resources locate within the project site and presents significant conflicting developmental characteristics and therefore there is the need for extensive consultations in determining suitable options of common interest so as not to disturb the heritage the settlers find consolation.

Green House Gas Emission

The principal sources of greenhouse gases emission in Ghana are identified to include agriculture, forestry, energy (fuel combustion, mobile combustion & fugitive emission), Industrial Processes and waste. Globally, Greenhouse gas emission (GHG) in Ghana is relatively insignificant compared to global emissions. The Total GHG Emissions Excluding Land-Use Change and Forestry in 2012 was estimated as 27.34 $MtCO_2e$ and the Total GHG Emissions Including Land-Use Change and Forestry in the same period was 58.84 $MtCO_2e$ including national annual CO_2 emission of 44.19 $MtCO_2e$

- **Impacts Identified and their Mitigation**

The project would involve the development, operation and decommissioning of 2X350 MW supercritical coal-fired power plant with affiliated coal handling terminal. The development is expected to result in a number of potential impacts arising from activities related to the pre-construction, construction, operational and decommissioning phases of the project.

The potential impact identification process involved comprehensive assessment of the potential source of impact of the project development and associated activities to predict and evaluate the potential effects on the physical, biological, social and cultural environment within the project area of influence.

During the construction phase the residual impact on air quality is expected to be minimal and therefore the operation is considered as minor and severity would be minor however occurrence is very likely.

The key receptors of noise impact include close by communities and residents and terrestrial fauna. The generated noise is also likely to cause nuisance to the workers and site visitors.

The principal receptor of wastewater would be nearby surface water, the sea and likely the groundwater as the sewage may be drained in to these water bodies. The residual impact is expected to be minor and the severity is rated as minor.

The main receptor of solid waste is the physical environment, which would receive the waste materials. Indiscriminate dumping of waste would be avoided to ensure proper management and disposal of the waste generated using the municipal authorities and waste management system. The impact on the receptor could be rate as minor and the severity could also be rate as minor and unlikely.

The main receptor of traffic impact could be the general public and other road users. In general, the impact would be minor as the traffic and transportation would be rather limited and can be managed and controlled effectively. Consequently, the severity would also be minor and unlikely.

The main receptors of occupation health and safety impact are the construction workers and the residents of the adjoining communities. Given the various mitigation interventions relating to dust generation, noise generation and exhaust gas emission and the limited duration of the impact, the impact could be rated as moderate and since the impact is considerably localized its severity could be rated as low.

The ecosystem of the proposed project site is noted to have very low fauna diversity and abundance. No species of international conservation interest was encountered in the project area. Three species of birds encountered in the area were completely protected by the Wildlife Conservation Regulation of Ghana. The proposed project is therefore unlikely to have any significant adverse impact on the fauna of the area due to the very low faunal population and poor species diversity currently in the project area. Also the impact zone (foot print) of the project is limited and therefore not expected to have any significant impact on wildlife within the area of influence and beyond.

The principal receptors of landscape and seascape visual impact likely to be affected are the local inhabitants especially who reside within the adjoining communities. Other receptors would be visitors who visit the beach for tourism and pleasure. The visual impact of the constructions works of the plant, although is expected to be more confined to the plant site, could be significant considering the high level disorganization and apparent aesthetic appearance of the vicinity in relation to the baseline situation. Also, the grid transmission lines create additional visual impact extended along the distance covered by the grid transmission lines. Similarly, the impact could be significant and rather extensive.

The benefits of development may be lost if attention is not given to managing the sensitivity associated with the impact of the people losing their traditional cultural and social identity. The mitigation is essential to minimize the residual visual impact.

In relation to greenhouse gases due to forest cover loss, according to the baseline data, the vegetation and forest cover have already been cleared for farming activities, consequently the vegetation and forest cover cleared for the predevelopment of project structure would be rather limited. Therefore, the significance of the potential impact would be minor.

The Project is envisaged to acquire large tract of land estimated to 139 hectares of land area for the development of infrastructure and installation of project facilities and would potentially result in loss of farmlands and related loss of income, displacement of residents and family disputes. The land acquired would be appropriately compensated using acquisition and compensation payment process complying to national regulatory requirements and international practices. The residual impact is expected to be minor, however the occurrence is likely.

The project would potentially have significant impact on this historical feature of the communities, causing these features to lose their original and traditional landscape setting, reverence and even beliefs.

Inclusive consultations with the chief priests and community leadership on the different deities would be crucial for proper management of the situation.

The socio-economic impact of the project demonstrates that the construction phase of the project would potentially affect previous land owners as they would be required to cease all economic activities on the land and evacuate any assets on the land, also influence fishing operation at the beach area and overall performance of the fishing sector, create significant expansion of the population with attendant demands on public facilities and public health and safety.

The key benefits include creation of decent job opportunities and incomes, improved public health and security facilities. The construction phase is envisaged to engage some 1000 workers in direct construction works while another 500 workers are expected to engage in indirect activities including drivers, security and cleaners. In addition, considerable indirect employment could be generated through contractors and other service providers and suppliers. Vendors would also emerge to provide food and catering services to the workers as well as trading in variety of items.

The operation of the power plant would generate flue gases, noise, effluent and other waste materials, which could have adverse impact of the environmental resources and potential receptors. On the other hand, the operation of heavy trucks and machinery and equipment could also be potential source of emission of exhaust fumes, dust particulate and noise.

The effect of the operation of the power plant is therefore envisaged to involve:

- Atmospheric emissions
- Noise and vibration generation
- Affecting the marine environment including fishes, mammals and reptiles
- Thermal discharge of process water, thermal plume and generation of wastewater, sewage and other waste materials.
- Environmental incidents and accidents (e.g. spillages, noise)
- Abstraction of seawater and discharge of warmer seawater into the Sea
- Affecting people including workers, visitor, community and society at large.
- Influencing the social and economic environment

The primary environmental concerns relating to impact of flue gas emission on air quality is the ground level concentration of pollutants including Suspended Particulate Matter (SPM), sulphur dioxide (SO_2) and oxides of nitrogen (NOx).

This plant emission control configuration incorporates:

- Preference to high-heat-content, low-ash, and low-sulfur coal as the primary choice of fuel;
- Choice of combustion technology; adopting supercritical pulverized

coal combustion;
- Electro-static Precipitator for removal of dust in flue gas;
- Seawater Flue Gas Desulfurization for removal and control of SO_2in the flue gas;
- Low NOx combustion and SCR for control NOx emission
- Designing stack heights according to Good International Industry Practice (GIIP) to avoid excessive ground level concentrations and minimize impacts, including acid deposition.

Accordingly, the emission dispersion modelling, the reported baseline concentrations of air pollutants were largely lower than the Ghana EPA ambient air quality guidelines but with TSP and PM level attained 26.19% and 76.06% respectively of the guideline standards, attributed possibly to the severe harmattan at the time of the measurements.

Table 1 Background Ambient Air Quality Concentrations at Proposed Project Site during Harmattan Season

Date	CO (µg/m³)	NO_2 (µg/m³)	SO_2 (µg/m³)	TSP (µg/m³)	PM_{10} (µg/m³)
Average	**714.31**	**4.19**	**62.15**	**60.23**	**53.24**
EPA Guideline	10000.00	150.00	150.00	230.00	70.00

Accordingly, the following ground level concentration (GLC) values of three criteria pollutants (NO_2, SO_2, and PM) were obtained based on modelled flue gas emission dispersion.

The modelled results indicated the maximum ground level concentrations (GLCs) for NO_2, SO_2, and PM from the coal-fired power plant will not present any significant adverse short- and long-term impacts on the receiving environment; given the stack height of 180 m and the proposed controls/mitigation interventions specified.

Table 2 Maximum Ground Level Predicted Concentrations from AERMOD Dispersion Modelling and Impact Analysis

	NO_2			**SO_2**			**PM**	
Average Period	**1-hr**	**24-hr**	**Annual**	**1-hr**	**24-hr**	**Annual**	**24-hr**	**Annual**
Project Impact (μg/m³)	90.41	13.47	5.50	102.00	15.20	6.62	3.28	1.43
Outfall Point, Easting (m)	740411.72	739911.72	740611.72	740411.72	739911.72	740611.72	739911.72	740611.72
Outfall Point, Northing (m)	576455.57	576955.57	577255.57	576555.57	576955.57	577355.57	576955.57	577355.57
Monitored Background Conc. (μg/m³)	4.19	4.19		62.15	62.15		60.23	
Total (Maximum GLC)	94.60	17.66	—	164.15	77.35	6.62	63.51	1.43
EPA Guideline	400	150		900	150	80	230	75
EPA Guideline Consumed (%)	23.65	11.77	—	18.24	51.57	8.28	27.61	1.91
Process Contribution to EPA Guideline (%)	22.60	8.98	—	11.33	10.13	8.28	1.43	1.91
Maximum Allowable Process Contribution (μg/m³)	263.87	97.21	—	558.57	58.57	53.33	113.18	50.00
Exceedance of Maximum Allowable Process Contribution (μg/m³)	-173.46	-83.74	—	-456.57	-43.37	-46.71	-109.90	-48.57
IFC/WB Ambient Guideline (μg/m³)		150	100		150	80	230	80
IFC/WB Guideline Consumed (%)	—	8.98	5.50	—	10.13	8.28	1.43	1.79
25% of EPA Guideline (μg/m³)	100.00	37.50	—	225.00	37.50	20.00	57.50	18.75

Note:

The emission dispersion modelling adopted ambient air quality concentration during the harmattan season for the background base condition. This is to present the worst case scenario for the ground level concentration.

The daily and annual total maximum Ground Level Concentration of sulfur dioxide (SO_2) are predicted to be 77.35μg/m³ and 6.62μg/m³ respectively, with the process contribution to EPA guideline appreciably low being 10.13% and 8.28% respectively. Similarly, the one hour and daily total maximum Ground Level Contribution of NOx predicted as 94.60μg/m^3 and 17.66μg/m^3 respectively and with process contributions to the Ghana EPA Guideline for NO_2 noted as 23.65% and 11.77% respectively for one hour and 24hour periods respectively. The highest daily predicted project contributions to the Ghana EPA guideline was noted for NO_2 (13.47 μg/m^3) at the maximum outfall point 728m at X: 739911.72; Y: 576955.57 and 968m at X: 740611.72; Y: 577255.57 northeast of the stack for daily and annual respectively). The maximum daily Ground Level Contribution for PM (63.51 μg/m^3) was predicted at 728m (X:739911.72; Y: 576955.57) northeast of the proposed stack location and ranked lower than the Ghana EPA and WB/IFC guidelines of 230 μg/m^3.

The project is projected to emit 3.69 million tonnes of Carbon dioxide into the atmosphere annually, constituting some 8% of the national annual CO_2 emission and 6% of the national annual GHG emission of 2012 stated as 44.19 million tonnes and 58.84 million tonnes respectively.

The project has considered CO_2 emission control interventions including:

- Adoption of low carbon coal,
- Adoption of higher energy conversion technology (super-critical boilers),
- Ensuring optimal design efficiency
- Low carbon offset interventions programme including:
    - Carbon sequestration potential of VRA Reforestation Programmes within Volta lake
    - Offsets from VRA's Combined Cycle Projects
    - Offsets from VRA's and SEC's Renewable Energy Programmes (Solar and Wind)
    - Carbon Accounting Programme beginning 2016

The principal sources of noise generation during the operational phase would mainly be the operating machinery and equipment, which would include Primary Air Fan, Forced Draft Fan, Induced Draft Fan, Air Compressor, Transformer, Turbine and auxiliaries, Generator, Crusher, Mill, Pumps, Aeration Fan, Coal Handling machines and conveyors, the boiler and auxiliaries etc.

The plant design also considered the use of noise control measure such as noise isolation and enclosure designs, adopting the use of silencers and mufflers where possible as well as sound absorbers including vegetation to minimize and control the ambient noise at the plant and other sensitive areas.

Also, the layout of the plant has been arranged to provide buffer in the front area.

A noise transmission modelling study has been conducted for the operational phase demonstrating that a maximum noise level of 83.19 dBA occurring at (X 76211.4, Y: 40397.65), which lies within the power plant boundary.

Table 3 Predicted Noise Levels of Sensitive Receptors (Main Communities) under Influence

Receptor location	**Predicted Noise Level (dBA)**			**EPA Guideline**	**Compliance Status**
	Modelled Noise (dBA)	**Average Background Noise (dBA)**	**Predicted Noise (dBA)**		
Aboano community	10	62.52	62.52	55	Not Compliant
Etsibeedu Community	38	64.68	64.69	55	Not Compliant
Otuam Community	12	61.85	61.85	55	Not Compliant
Kontankore Settlement	20	59.56	59.56	55	Not Compliant

The significance of the noise emission and the severity of the residual impact is can be considered as effectively controlled if maintenance practices are well managed accordingly to the manufacturers recommended preventive maintenance schemes. Consequently, the probability of occurrence of the nuisance would be rated unlikely and hence the residual impact would be low. Also the cumulative impact would be low.

The operation of the coal-fired power plant would involve utilizing the seawater for cooling in a once through circulation system to condensate steam from the turbine, and further a portion of the seawater is used for removal of sulphur dioxide from flue gas in the seawater FGD system. Additionally, the seawater is demineralized and used for boiler make-up and other service water including coal and ash handling.

A plume Modelling has been conducted to effectively determine the thermal plume characteristics (maximum discharge temperatures) and appropriate discharge characteristics (flow rates), which ensures effective mixing and minimum impacts of the thermal plume on the marine ecological resources. The temperature at the edge of the mixing zone is predicted as 2.97^{0}C. The results also suggest that the water quality standard of 3^{o}C above ambient water is achieved at plume location of 86.05m

Measures to control impacts of the once through circulation cooling system on the marine ecology involve appropriately design in the intake to allow side entry and controlled the intake velocity to such low rate, less than 0.3m/s; intake velocity perpendicularly aligned to the direction of the current and intake provided with grid drum whiles arranged to prevent obstruction of ships.

Measures to prevent, minimize and control thermal discharge and associated impacts from the once through circulation cooling system include adjustment of the discharge temperature, flow, outfall location, and outfall design to minimize impacts to acceptable level. The Once through Circulation Cooling System may potentially cause impingement and entrapment of aquatic organisms, especially depending on seasonal factors, current characteristics, weather conditions and abstraction velocity.

The Once through Circulation Cooling System may potentially cause impingement and entrapment of aquatic organisms, especially depending on seasonal factors, current characteristics, weather conditions and abstraction velocity

The wastewater streams in the power plant would include waste water from ash handling and storage runoff; boiler blow down and cleaning waste, back wash from demineralization plant, wastewater from ESP wash, cleaning wastewater, storm drains, laboratory wastes and wastewater from water purification and waste water treatment units and Sewage and other sanitary wastewater.

The principal contaminants would include coal and ash particle sand related heavy metals including arsenic mercury and lead; chemicals including fluorine, chlorine, biocides and other related chemicals for managing the quality of cooling water; and traces of fuel oil and lubricants. All waste water from the plant would be treated separately, and then reused for green in the plant, or humidifying ash and slag, and cleaning water.

The Coal-fired power plant would generate significant solid waste in the form of coal ash residues from the coal fuel during the operational processes. The waste includes fly ash, bottom ash and boiler slag. Ash and slag generated from the coal fired power plant would be stored only temporarily.

The ash residues may contain heavy metal and some organic compounds or potentially hazardous materials. Measures to prevent, minimize, and control the volume of solid wastes from thermal power plants Recycling of CCWs in uses such as cement and other concrete products, and construction fills. Two Chinese companies have already signed MOUs with the project to develop comprehensive utilization of the coal ash in Ghana.

Soil erosion is a potential impact considering the project characteristics, against the existing local soil erosion situation, natural conditions and other factors. The project has considered balancing the earthworks to ensure that the net impact is minimal, development of green designed areas, setting land scape in three steps with drains suitably placed on the periphery to facilitate and ensure effective drainage of storm water from the site.

Coal and ash storage facilities are constructed with appropriate protection at the bottom, including composite geo-membrane set on the surface of bottom and inside slope for the ash storage yard to prevent permeability of hazardous substances.

Hazardous materials may include solid, liquid, and gaseous fuel-based waste and water treatment chemicals; and equipment and facility maintenance chemicals. Measures to prevent, minimize, and control hazards associated with hazardous materials storage and handling include the use of double-walled, underground pressurized tanks for storage.

During operation of the power plant, traffic nuisance is expected to be negligible as there would be very limited transportation.

Potential sources of fire include gas leakage from the hydrogen generation plant and generator cooling system, oil spill and leakage from the transformer cooling system, lubricating oil system and light diesel oil storage for the boiler back-up start fuel.

The operation of the power plant may cause a number of occupational health and safety risks and impacts, which may include Non-ionizing radiation, Heat, Noise, Confined spaces, Electrical hazards, Fire and explosion hazards, Chemical hazards and Dust.

Operation of the power plant and affiliated facilities may cause dust and noise nuisance to the worker and could lead to respiratory problems and hearing lose respectively. Additionally, ground level gas concentration may be significantly high and could cause nuisance to the worker.

The workers would have higher risk being exposed to electric and magnetic fields (EMF) due to consistent proximity to electric power generators and related equipment and the high-voltage transmission lines. Occupational EMF exposure would be prevented or minimized through the preparation and implementation of an EMF safety program.

Exposure to heat may occurs during operation and maintenance of combustion units, pipes, and related hot equipment. Prevention and control measures would include

ensuring the integrity of insulation of combustion units, pipes and related hot equipment by regular inspection and maintenance the identified facilities; ensuring all work areas are adequately ventilated to reduce heat and humidity; reducing exposure time, ensuring Personal protective equipment (PPE) are appropriately used and adopting suitable warning signage.

Occupational health and safety risk may arise due to workers' exposure to identified noise sources.

Specific areas for confined space entry may include coal ash containers, turbines, condensers, and cooling water towers. These areas would be appropriately designated with specific operational instructions.

High voltage transmission lines and related equipment present electrical hazards for workers of the power plant. Measure to prevent, minimize, and control electrical hazards include appropriate work procedures, consistently providing specialized electrical safety training to workers and proper use of PPE, and proper lockout/tagout procedures.

Thermal power plants store, transfer, and use large quantities of fuels resulting in higher fire and explosion risks. In particular, fire and explosion hazards increase as the particle size of coal is reduced especially around thermal dryers, cyclones, baghouses, pulverized-fuel systems, grinding mills, and other process or conveyance equipment. Control measures include the use of automated combustion and safety controls; proper maintenance of boiler safety controls; implementation of start-up and shutdown procedures to minimize the risk of suspending hot coal particles (e.g., in the pulverizer, mill, and cyclone) during start-up.

Exposure of workers to chemical and chemical fumes increases the health and safety risks. Measures adopted to prevent, minimize, and control physical hazards include appropriate education of workers on handling and management of chemicals in accordance to MSDS and providing appropriate information as contained in the MSDS; use of suitable personal protective equipment including nose mask and goggles.

Dust generated during operational activities may contain potentially harmful substances that could create health and safety impacts on workers. Measures to prevent, minimize, and control occupational exposure to dust within and outside the plant would involve adopting of dust controls within area of fugitive dust and use of appropriate personal protective equipment.

The risk to the community health and safety include exposure to high residual emissions, noise and vibration nuisance, non-ionizing radiation generated by the power transmission grid, visual impact of changed landscape, and traffic nuisance and the consequence potential health risk due to degraded air quality, visual impact and resulting emotional stress and increased public insecurity.

The influx of migrant workers both national and international presents considerable social challenges including increased demand on community health and educational facilities and social vices. The community is likely to experience upsurge of sex workers and attendant health hazards including HIV AIDS.

The socio-economic benefits of the project during the operational phase would include creating direct or indirect employment opportunities for both skilled and unskilled labour, enhancing skills development and good localization opportunities. It is estimated that the project would provide some 1,500 people with decent jobs and incomes.

The project would also provide additional electricity generation capacity contributing to meeting electric power shortfall in Ghana and promoting local economy development while stimulating the development of related industries such as manufacturing, transportation and commerce.

The decommissioning phase of the project would involve dismantling and removal if installations and associated development facilities where practicable.

The potential impacts of the activities may include increased levels of noise; appropriate disposal of unserviceable equipment parts and machinery; increased vehicular transportation of serviceable components and equipment; disposal of on-site infrastructure debris; Occupational hazards; and related Socio-economic (workers' layoff and compensations, loss of power generating capacity and power supply).

The mitigation measures have been developed to address the residual impact remaining after design mitigation measure and the possible cumulative impact.

Constructional Phase

Environmental Parameter	**Potential Impact**	**Significance / Occurrence**	**Proposed Mitigation**	**Residual Impact**	**Residual Severity**
Air	Degradation of ambient air quality and attendant effect on workers and neighbouring communities	Moderate and very likely	Construction Contractor to implement dust suppression techniques on construction surfaces Provision of tarpaulins for trucks delivering sand and gravels to the site. Regular maintenance of construction vehicles and heavy machinery and equipment. The exhaust emissions of vehicles and heavy machinery and equipment would be monitored and controlled.	Minor	Minor and likely
Noise	Nuisance to workers and residents of neighbouring communities	Moderate and likely	Regular maintenance of machinery and ensuring noise from the machinery is low Working areas on the project site would be fenced Working periods would be controlled and would be between 7:00 am to 6:00 pm	Moderate and likely	Minor

Environmental Parameter	Potential Impact	Significance / Occurrence	Proposed Mitigation	Residual Impact	Residual Severity
Traffic	Congestion and accidents	Moderate and likely	Trucks would be appropriately marked with reflectors and warning signs indicating long vehicle and speed limits to caution other drivers	Low impact is exppected	Minor and unlikely
Water Resources	• Contamination of groundwater and surface water. • Damage to aquatic environment and fishery activities	Moderate and likely	Treatment of sewage. Construction Contractor would adopt strict fuelling and spill control procedures. Where practicable, all fuel storage areas would be secured. Develop spill response and management plan and measures.	Minor and likely	Minor
Land	• Indiscriminate Waste disposal • Contamination of soil • Soil erosion • Landscape visual impacts	Moderate and likely	• Development of a Waste Management Plan. • Waste Management Training of construction personnel. • Secure fuel storage areas and develop strict fueling and spill control procedures • Develop greening and landscape management scheme	Minor and likely	Minor
Ecology	Disturbance to the terrestrial ecosystem	Moderate and likely	Control of construction activities ensuring mammal have ample time to migrate.	Minor and likely	Minor
	Disturbance to the marine ecosystem and mammals	Moderate and likely			

Environmental Parameter	**Potential Impact**	**Significance / Occurrence**	**Proposed Mitigation**	**Residual Impact**	**Residual Severity**
Occupational Health and Safety	• Health risks and possibilities of respiratory problems, hearing impairment • Potential accidents including electrocution fall etc. resulting in injuries and fatalities	Moderate and unlikely	• Health and Safety education and awareness • Provision and appropriate use of personal protective equipment • Use of suitable clothing • Emergency response plan • Monitoring and reporting scheme established	Minor and unlikely	Minor
Socio-economic	• Increased economic activities (trading) and competition for local economic operators • Decent jobs for local inhabitants (unskilled labour) and income opportunities • Increased local population • Loss of farmland and reduced farming output	Moderate and likely	• Stakeholders engagement and monitoring scheme established • Appropriate compensation of farmers for loss of land and crops • Adequate education of the farmers	Moderate and likely	Moderate

Environmental Parameter	Potential Impact	Significance / Occurrence	Proposed Mitigation	Residual Impact	Residual Severity
Community Health and Safety	• Potential health risk due to degraded air quality, noise and vibration, visual impact and resulting emotional stress. • Potential increase in traffic accidents • Increased public insecurity • Increased community population and attendant demand on community health and educational facilities	Moderate and likely	• Improved public health facilities and management • Increased public education and sensitization • Traffic and transportation management plan • Controlled public access to construction sites and restricted areas • Public security management plan (improving Police Post) • Institution of grievance mechanism • Public Health and Safety Management Plan	Minor and unlikely	Minor

Operational Phase

Environmental Parameter	Potential Impact	Significance / Occurrence	Proposed Mitigation	Residual Impact	Residual Severity
Air	Deterioration of air quality and attendant effect on human health. According to the emission dispersion modelling study the ground leve concentration (GLC) of the emission pollutants, SO_2, NOx and PM, are all below the respective EPA guideline values	Minor and unlikely	• Ensuring coal and ash handling and storage areas dust controls are fully functional and regularly monitored. • Ensuring stack emission controls are functional and regularly monitored. • Five continuous emission monitoring systems would be installed at designated locations. • Air quality measurement and audits would be done periodically to validate the level of concentration of emission pollutants.	Minor and unlikely	Minor
Noise	Nuisance to workers and residents of neighbouring communities	Moderate and unlikely	• Machinery and equipment would be provided with acoustic casing where appropriate. • Regular maintenance of machinery and equipment and also ensuring noise from the machinery and equipment is low. • The designated high noise operational areas are appropriately shielded with noise absorbing	Minor and unlikely	Minor

Environmental Parameter	**Potential Impact**	**Significance / Occurrence**	**Proposed Mitigation**	**Residual Impact**	**Residual Severity**
			fencing including shrubs and trees. • Workers and visitors would be provided with suitable PPEs		
Traffic	Increased traffic and related congestion and accidents	Minor and unlikely	• Staff movements would be coordinated and planned to promote group movement. • Use of mass transported where appropriate and restricting individual movements.	Minor and unlikely	Minor
Waste	Generation of waste andindiscrimitate disposal and the associated impacts.	Minor and Unlikely	• Development of Waste Management and Monitoring Plan for the operational waste. • Ensuring appropriate waste management practices would be strictly enforced. • Adequate provisions would be made for effective and efficient waste management.	Minor and unlikely	Minor
Land	• Soil erosion and contamination and related land degradation. • Land use restriction • Land scape visual impact	Moderate and likely	• Greening scheme and soil protection using composite geomembrane for coal ash storage area • Periodic monitoring of soil quality • Develop landscape management plan and monitoring scheme.	Minor and unlikely	Minor

Environmental Parameter	Potential Impact	Significance / Occurrence	Proposed Mitigation	Residual Impact	Residual Severity
Sea water	Deterioration of seawater quality and temperature from discharge of process water Contamination of seawater by coal ash	Minor and unlikely	Continuous monitoring to ensure that the temperature of the mixing zone remains within the stipulated 2^0C above ambient seawater temperature and the quality of seawater also remains within acceptable standards.	Minor and unlikely	Minor
Ecology	• Disturbance to the terrestrial ecosystem • Disturbance to the marine ecosystem	Minor and unlikely	Continued periodic monitoring of the terrestrial and marine environment.	Minor and unlikely	Minor
Occupational Health and Safety	• Health risks and possibilities of respiratory problems, hearing impairment • Potential accidents including electrocution, irradiation, fall etc. resulting in injuries and fatalities	Moderate and likely	• Health and Safety education and awareness • Provision and appropriate use of personal protective equipment • Use of suitable clothing • Emergency response plan • Monitoring and reporting scheme established	Minor and unlikely	Minor
Socio-economic	• Increased economic activities (trading) and competition for local economic operators • Decent jobs for local inhabitants (unskilled labour) and income	Moderate and likely	• Stakeholders engagement and monitoring scheme established • Restricted sea areas would be clearly demarcated • New fishing route established and alternate fish landing practices encouraged	Moderate and likely	Moderate

Environmental Parameter	Potential Impact	Significance / Occurrence	Proposed Mitigation	Residual Impact	Residual Severity
	opportunities • Increased local population • Loss of access to fishing area and disturbance to fishing operation. • Increased fish catch due to additional illumination and increased sea depth • Loss of farmland and restricted farming practices • Improved fish landing site and handling		• Appropriate compensation of fishermen and farmers • Adequate education of the fishermen • Two suitable landing sites created and provided with appropriate facilities		
Community Health and Safety	• Potential health risk due to degraded air quality, visual impact and resulting emotional stress. • emotional stress • Potential increase in traffic accidents • Increased public insecurity • Increased community population and attendant demand on community health and educational facilities	Moderate and likely	• Improved public health facilities and management • Increased public health education and sensitization including STD. • Traffic and transportation management plan • Controlled public access to construction sites and restricted areas • Public security management plan (improving Police Post) • Institution of grievance mechanism • Public Health and Safety Management Plan	Minor and unlikely	Minor

- **Monitoring and Any Other Critical Matters**

An Environmental Monitoring and Evaluation Programme would be instituted to monitoring the various phases of the project development.

Monitoring areas during the project Constructional Phase would include:

a) Air quality (Particulate Matter, Sulphur dioxide, oxides of Nitrogen, and Carbon Monoxide)
b) Noise
c) Resource use efficiency

Monitoring areas during the project operational phase would include:

a) Air quality, particularly monitoring stack emissions and ambient air quality for concentration of air pollutants such as Suspended Particulate Matter, Sulphur dioxide, oxides of Nitrogen and Carbon monoxide at defined locations within the plant area and the communities. Five continuous monitoring stations would be set up. Furthermore, the monitoring would validate the completeness of control equipment installed for minimizing the emission of pollutant from stack and adequacy and performance of monitoring facilities provided.

b) Effluent from the plant would be monitored after treatment before discharge to ensure compliance to EPA Standards and IFC guideline; and seawater shall be monitored for heavy metal pollution.
c) Seawater temperature would be monitored continuously and monitoring of the marine environment would be conducted monthly.
d) Noise level at various locations within the plant and outside plant area within the nearby communities would be monitored consistently and on monthly basis.
e) Soil contamination is likely and therefore monitoring soil quality and especially for heavy metal contaminants.
f) Handling and management of coal ash would be monitored closely through daily inspections
g) Availability and use of personal protective equipment would be continuously monitored throughout the various phases of the project.
h) Overall performance and resource use efficiency would be monitored monthly.

The Project would establish monthly reporting scheme and submit the reports, including quarterly and annual reports accordingly as required by EPA to meet national compliance requirements

A Provisional EMP outlining the necessary environmental management planning and commitment to prevention and minimization of any potential residual impacts to acceptable levels of environmental quality, health and safety standards and where necessary compensation payment to alleviate potential impact would be considered. The Environmental Management Plan seeks to establish an Environmental and Social Management System (ESMS) to ensure that mitigation measures are conducted effectively and efficiently to minimize the impacts of the power plant and affiliated facilities. The ESMS is particularly developed to include the organizational structure, planning and resources for developing, implementing and maintaining the project corporate policy for environmental protection.

The relevant sections of the Provisional EMP comprise:

a) Mitigation plan (on-site and off-site, construction and operation)
b) Monitoring plan (on-site and off-site, construction and operation)
c) Emergency response plan
d) Training and awareness creation programmes
e) Documentation and reporting
f) Financial requirements for effective plan implementation

The Provisional Environmental and Social Management Plan would incorporate an Environmental and Social Management System (ESMS), which will be enforced to ensure compliance to all relevant environmental quality guideline. The ESMS will integrate various management systems and plans including:

a) Compliance Management Plan
b) Waste Management Plan
c) Resource Efficient Management Plan
d) Health and Safety Management Plan
e) Air Quality Management Plan
f) Emergency Preparedness and Response Plan

- **Decommissioning**

Decommissioning of the power plant would become necessary due to obsolescence of the power plant with low efficiency; progressive difficulties in meeting the allowable emission levels and therefore demanding pollution controls making it economically uncompetitive and the Power plant having outlived its useful economic life and becoming increasingly uneconomic to operate.

Key considerations would be taken into account in decommissioning the coal-fired power plants including economic model, technology assessment and environmental issues and also options for the site. Seeking professional assistance in this regards would be given due consideration from the beginning.

It is considered that the power plant decommissioning would involve primarily demolition and remediation. The specific activities would include Permitting, Environmental and ecology assessment including ground investigation, noise mitigation and pollution, Structural demolition, Site dismantlement and scrap recovery, Waste disposal, Environmental clean-up, Site remediation and restoration, Precautionary legal solutions and Costing.

The Project would engage the services of professional demolition contractors to carry out the work and ensure appropriate measures would to be taken to prevent unnecessary or undue degradation. Depending on the market for scrap metal, the dismantled coal-fired power plant may be sold to the local steel industry or reshipped to China to offset substantial cost. Auxiliaries such as pumps, piping, boilers, ductwork and air pollution controls will require special handling.

- **Conclusion**

In conclusion, VRA and SEC have conducted comprehensive assessment of the Environmental and Social Impact of the proposed 2X350 Supercritical Coal-fired Power Generating Plant to be situated along the coast of Aboano in the Ekumfi District of the Central Region.

Consequently, following careful evaluation of the project design and the comprehensive environmental pollution controls; and having identified and assessed the likely residual impacts and recommended appropriate mitigation measures to eliminate, minimize or compensate where necessary; it is concluded that the development and operation of 2X350 MW Supercritical Coal-Fired Power Plant is unlikely to have significant adverse effect on the environment and climate change.

The health and safety situation of the workers and the community is not likely to be affected any significantly by the implementation of the project development. However, the project, in general is likely to provide immense social and economic benefits to the surrounding communities and the nation as a whole; providing decent jobs and consistent income flow to stakeholders directly and indirectly, technology transfer and diffusion as well as boosting the commercial activities of the people. In addition, the project would supplement power generation capacity and improve supply stability and security creating the needed base for the development of renewable power generating sources to meet the continued growing energy needs of the country both presently and in the future.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBRIVIATIONS

VRA	Volta River Authority
SEC	Shenzhen Energy Group Co., Ltd.
CHT	Coal Handling Terminal
MOF	Material Offloading Facility
FGD	Flue Gas Desulfurization
ESP	Electro-static Precipitator
SCR	Selective Catalytic Reduction
SNCR	Selective Non-Catalytic Reduction
RO	Reverse Osmosis
UF	Ultra Filtration
EDI	Electro Deionization
DWT	Dead Weight Tons
M	Meter
MM	Millimeter
HP	Horse Power
HVAC	Heating, Ventilation and Air Conditioning
NO_X	Nitrogen Oxides
SO_x	Sulphur Oxides
COx	Carbon Oxides
PM	Particulate Matter
NEQG	National Environmental Quality Guideline
Tph	Tons per Hour
Tpd	Tons per Day
Tpa	Tons per Annum
IGCC	Integrated Gasification Combined Cycle
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
AOI	Area of Influence
CEMS	Continuous Emission Monitoring System
BMCR	Boiler Maximum Continuous Rating
CW	Cooling Water
IFC	International Finance Corporation

1 INTRODUCTION

1.1 Background

Shenzhen Energy Group Co., Ltd. (SEC) and Volta River Authority (VRA) are collaborating to develop a 2×350MW supercritical coal-fired power generating plant with affiliated coal handling terminal which would be situated at Aboano Ekumfi along the coastline of Ghana facing the Atlantic sea.

1.1.1 Profile of Shenzhen Energy Group Co., Ltd

The Shenzhen Energy Group Co., Ltd. was incorporated in 1991 in China and became listed on the Shenzhen Stock Exchange in 1993. The current structure of the general share capital of Shenzhen Energy is 3,964,491,597shares, configured as 1,896,000,775 shares held by Shenzhen Municipal People's Government State-owned Assets Supervision and Administration Commission, accounting for 47.82% of the general capital; 991,741,659 shares are held by Huaneng Power International Inc., accounting for 25.02% of the general capital; and 1,076,749,163 shares are held by other shareholders, accounting for 27.16% of the general capital.

SEC is the first large joint-stock company in the national power industry and also the first utility stock company to be listed on Shenzhen Stock Exchange. SEC is therefore largely publicly owned and has remained seriously commitment to its social responsibility and public accountability, consequently its aspirations of generating green power for the future.

Through the years SEC has developed its core business in power generation with environmentally friendly energy, gas business and related energy finance as subsidiary business both on the Domestic and International markets. Currently SEC has more than twenty subsidiaries, creating strategic pattern with energy generation as the core business and dominating the operations. These enterprises include two public-listed companies, three coal-fired power plants, five gas power plants, six waste-to-power plants, a number of solar power stations and an ocean fleet with six Panama bulk carriers.

At the end of 2014, the total installed capacity controlled by SEC was 9060 MW including the waste-to-power plants demonstrating the comprehensive development policy of the group. SEC ranks among the top 500 enterprises in the China, which have created the good image of "integrity, merit, standard and environmental protection".

One of SEC's primary strategic positions is being an innovative and competitive low–carbon power provider, an innovative and competitive technology solution provider and an investor in municipal solid waste treatment.

Since inception, Shenzhen Energy has pursued scientific orientation as the strategic direction combining the business philosophy of "safety first, cost primary, benefit oriented and environment friendly" to strengthen the work style of doing good job, optimized management and controlled risk in the full realization of "responsible energy, powerful energy, environmental energy and harmonious energy".

By the end of 2014, SEC had attained energy generation mix, which had increased the proportion of clean energy to 59.10% from less than 3% ten year ago. The renewable energy projects have been important strategic pillar of the group's energy development, which include 418MW wind power projects for grid-connected power generation, 163MW photovoltaic power generation projects for grid-connected power generation and 147MW hydroelectric projects for grid-connected power generation out of the more than 500MW exploitable hydroelectric resource obtained.

Shenzhen Energy has insisted on the highest environmental protection standard while significantly expanding its power generation industrial set-up. SEC has also relied on the garbage treatment industry to actively develop waste to energy as an energy environmental protection industry. Shenzhen Energy presently treats over 7,050 tons of garbage daily and emission index of the plants has been up to or superior to EU standards; presently, Baoan Garbage Power Plant processing 4,200 tonnes per day is the largest garbage incineration power plant with the highest standard in China.

Presently, SEC operates three coal-fired power plants, which are identified to include Shenzhen Energy Mawan Power Plant (1,910 MW), Shenzhen Energy Heyuan Power Plant (I,200MW) and Shenzhen Energy Guangshen Shajiao B Power plant (700MW). Meanwhile, two additional supercritical power plants are in the construction phase, namely Shenzhen Energy Korla Power Generation

Corporation (2x350MW) and Shenzhen Energy Baoding Power Generation Corporation (2x350MW).

1.1.2 Profile of Volta River Authority

Volta River Authority (VRA) is solely owned by the Government of Ghana and was established in 1961 by the Volta River Development Act, Act 46 of the Republic of Ghana to generate and supply electricity for the country. Presently, VRA is the largest power generation company in Ghana combining hydro, thermal and solar plants to generate electricity for supply to the local and West Africa Regional markets.

The local market for power comprise of Electricity Company of Ghana, demand and supply for the mining operations and industrial operations, whiles the export market is constituted by demand and supply to Communauté Electrique du Benin (CEB) (for the Republics of Togo and Benin) and Société Nationale d'électricité du Burkina (SONABEL) (Burkina Faso).

In the past, electricity generation and supply in Ghana has been dominated by hydro power, which accounted for all the generation capacities until the late 1990s. However, presently the situation has changed and since the end of 2010 and Ghana's total installed thermal generating capacity has almost equalled the existing hydro generation capacity.

VRA hydroelectric power generation plants are situated at Akosombo and Kpong; also the thermal plants are situated mainly in Tema (Tema Thermal 1 & 2, Mines Reserve Plant and Kpone Thermal), and Aboadze in Takoradi (Takoradi Thermal Power Station T1, TICO/T2 and T3). At close of 2016, the total installed generation capacity was 2,340 MW with a dependable capacity of 2,107 MW. Currently, the thermal power generation plants using crude oil and gas as the fuel source play significant role in the power generation mix of VRA. VRA also operates a solar plant with installed capacity of 2.5 MW situated in the Northern Region of Ghana.

VRA has subsidiaries, which also create relevant strategic pattern supporting its leading operations, including Northern Electricity Distribution Company (NEDCo), Akosombo Hotels Limited, Volta Lake Transport Company and Kpong Farms Limited. Furthermore, VRA runs Health Services, Schools and Real Estate Departments, which are also developed as part of the Strategic Business Units.

VRA has also supported the socio-economic development of the Volta Basin; operating as a local authority for the Akosombo Township and exercising administrative responsibility over the Akuse and Aboadze Estates. The

Authority implements Environmental Management Programmes to mitigate the adverse impacts of its operations.

1.2 Purpose and Objectives of the Project

The 2×350MW supercritical coal fired power project would be developed; providing electricity to serve mainly Ghana.

The purpose of the project is to developed power generating plant contributing to creating highly stable and reliable power supply base and solving the serious domestic power supply volatility experienced in Ghana over recent years. Additionally, the power plant is envisaged to contribute significantly to addressing potential power demand and supply growth in-balance and deficit in the near future.

Specifically, the project is developed to serve the following:

a) Meeting the anticipated electricity demand growth in Ghana with the peak demand forecast for 2020, 2025 and 2030 projected as 3652MW, 4960MW and 7000MW respectively. According to a study by GRIDCo, the power balance results show considerable power supply shortfall with generation deficit for 2020, 2025 and 2030 envisaged as 879MW, 1015MW and 3423MW respectively. Consequently, Coal Fired Power Plant (phase I 2×350MW) coming on stream in 2020 will provide broader electricity supply market space.

b) Optimizing the power generation portfolio and improving generation mix and power supply stability and reliability in Ghana. The current primary energy generation sources in Ghana have experienced serious limitations due to low water levels and oil and gas supply constraints. Coal presents stable and reliable source and is available in South Africa and on the international coal market at highly stable price. This will reduce Ghana's vulnerability to short- and long-terms disruptions and ensure continuous supply of power to consumers. The Coal Fired Power Plant would therefore optimize the power generation mix and improve power supply reliability.

c) Providing favourable fuel price and offering lower power generation unit electricity price advantage. Coal is affordable source of energy, with coal cost, being historically more stable and favourable than oil and gas prices. The generation cost of coal-fired units is relatively low; accordingly, the coal fired units offer on-grid price advantage.

The objective of the project is to attain established highly stable and reliable cost-efficient electric power generation source to expand the power generation mix in Ghana and provide high-level availability of the power supply source.

Hydropower and thermal plants have been the primary sources of commercial electricity generation and supply in Ghana, for both the Ghanaian domestic and West African export markets. In addition, Ghana relies on electricity import from Cote d'Ivoire to supplement its domestic supply.

The overall performance of the electricity sub-sector in 2014 showed only 0.3%[1] growth, which was considerably less than the annual growth of 7% in demand for electricity. The low growth of the electricity sub-sector was attributed to several factors including the reduced volume of water in the catchment basins available to Akosombo, Kpong and Bui hydro-electric dams resulting from decreased rain pattern.

The total installed capacity of the power grid in Ghana and the electricity generation mix at close of December 2015 is provided in ***Table 1-1***.

Table 1-1 The Electricity Generation Mix (End of December, 2015)

Source	Installed (MW)	%	Total Electricity generation GWh	%
Hydropower	1580	43.2	5845	50.86
Thermal	2053	56.2	5644	49.11
Solar	22.5	0.6	3	0.03
Total	3656	100	11492	100

Source: National Energy Statistics 2006-2015; Energy Commission

Indicatively, though hydropower accounted for 43.2% of the installed capacity, yet its contribution to the total electricity generation was 50.86%; while thermal plants accounting for 56.2% of the installed capacity however only contributed 49.11% of the total electricity generated. The indications therefore emphasize that despite the reduced volume of water in the catchment basins of the dams and the consequent low output performance, hydropower performed considerable higher than the thermal plants. This situation illustrates the weak condition of thermal power generation using oil and gas. Furthermore, the situation reflects weak base for energy independence, energy security and supply reliability of the traditional primary sources of power generation. The situation therefore emphasized the need for diversification of the energy generation sources to address the possibilities of fuel supply risk.

According to GRIDCo, the annual demand projections are considerably high and are provided in ***Table 1-2***.

[1]The State of Ghanaian Economy, ISSER 2014.

Table 1-2 High Energy Demand (Annual Projections by GRIDCo – 7%)

Year	**2015**	**2018**	**2019**	**2020**	**2025**	**2030**	**Growth Rate**
Energy Demand (GWh)	17,717	22,304	23,573	24,953	33,754	47,342	6.8%
Peak Load (MW)	2,574	3,256	3,446	3,652	4,960	7,000	6.9%

Source: GRIDCo

Ghana's future energy demands and peak loads demonstrate consistent growth in the next 15 years (2015 to 2030) from 17,717GWh to 47,342 GWh and 2,574MW to 7,000MW respectively. A risk review of the natural gas supply reveals the following:

Table 1-3 Fuel Supply Risk (Natural Gas Supply)

Fuel Supply Sources (mmscfd)	**2015**	**2020**	**2025**	**2030**	**2036**	**Remark**
Indigenous Gas	127	313	242	211	51	Erratic & Limited Supply
WAPCo	123	123	123	123	123	Unreliable Supply & Pipeline Challenges
Total Supply	250	436	365	334	174	Supply Shortfall
Total Demand	450+	450+	450+	450+	450+	Increasing Demand
Deficit						LNG Augmentation

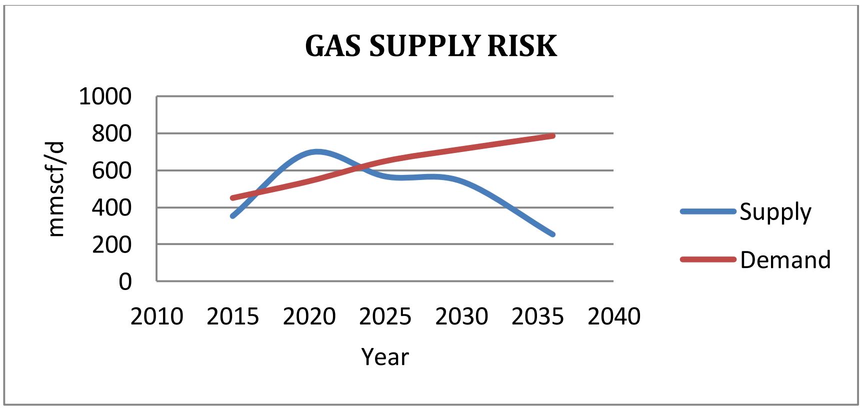

Figure 1-1 Natural Gas Supply Risk

The demand for alternative source of power generation that offers diversification of the energy source, energy independence and energy security to achieve improved supply reliability and addressing generation shortfall has become more crucial.

The diversification is more crucial to manage the generation shortfall associated with hydro, gas and liquid fuel; particularly regarding period of insufficient rainfall pattern associated with hydropower, high price volatility in relation to Light Crude oil.

Selection of Coal as alternative fuel source offers considerable benefits including:

a) Generation Shortfall

   Provide additional generation source for the 7% projected annual energy demand growth.

b) Diversification of Fuel Source

   With the indigenous gas resource set to run out in 2036, reduce our exposure to global energy markets & commodity speculators, and period of insufficient rainfall coal provides the best alternate fuel source to ensure continuous power generation for stainable development.

c) Energy Independence /Security

   Provide based load- electricity with the cheapest and unrestricted fuel, only next to large hydropower plants like Akosombo Generation Station. (i.e. Supply Reliability &Price Stability).

d) Benefits to Consumer

   Affordable source of electricity. Cheapest fuel in the long term invariable provides least economic cost of electricity (only next to large hydropower plants) for stainable development.

e) Increase Government Revenue
   Provide additional revenue to Government from taxes and levies.

f) Job Creation
   During project construction and operational phases as well as reforestation programmes

g) Increase the country's forest cover

Since 2000, China's economy has industrialized very rapidly and extensively, fueled to a significant degree through the use of coal[2]. China has installed some of the largest, most advanced coal-fired units in the world, incorporating modern SO_2, NOx and particulate control systems.

1.3 Rationale of ESIA

In accordance with the Environmental Protection Agency Act 1994, Act 490 (parts I&II) and Environmental Assessment Regulations 1999, LI 1652, the National Environmental Policy institutes and implements an environmental quality control programme requiring prior Environmental Impact Assessment of all new investments that would be deemed to affect the quality of the environment.

As part of the Environmental and Social Impact Assessment Process, a scoping report was prepared on the project and submitted to EPA for review. Following review of the Scoping Report, EPA advised that the ESIA process should consider separate reports on the power plant and the port facility to ensure that issues related to port development are considered duly.

This ESIA report is therefore confined to the 2x350MW Supercritical Coal-fired Power Plant and delinked from the power evacuation Transmission Line and the affiliated 70,000 DWT Coal Handling Terminal. The ESIA reports for the Power Transmission Line and the Coal Handling Terminal are prepared separately.

The rationale for the environmental and social impacts assessment therefore aims to achieve:

a) Compiling all relevant information relating to the proposed 2X350MW supercritical coal fired power plant and affiliated facilities to inform the permitting process of the project to minimize environmental impacts.

b) Identifying all important receptors and assessing the residual potential environmental impacts of project prior to the start of the project.

c) Determining the significance of impacts and identifying mitigation measures to alleviate any significant adverse impacts.

d) Ensuring modern, precautionary control alternatives are well considered and incorporated into design.

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[2] Emission Reduction through upgrade of Coal-Fired Power Plant; Learning from Chinese Experience, Partner Country Series, International Energy Agency OECD/IEA, 2014

e) Developing sustainable environmental management practices.

The Environmental Assessment Procedure involves:

a) Registration
b) Screening
c) Scoping
d) ESIA Study
e) ESIS Review
f) Decision Making

Methods by which information and data were obtained include:

1. Desk research, involving review of available documentations of relevant project information and data including project feasibility study and various related design studies.

2. Consultations with various stakeholders in various forms to discuss varied issues of interest and concerns to identify potential impacts and implications and the possible mitigation measures that need to be considered and addressed; these included:
    a. interview with community leadership, residents and identified groupings;
    b. public hearing,
    c. direct dialogue and
    d. focused group discussions with government agencies, regulatory agencies, Civil Society Groups, affected communities, local authorities and other interest groups identified;

3. Conducting field inspections, surveys and interviews to gather primary data and information on the various aspects of the projects; the brief profiles of the team of consultants are attached as appendix

4. Conducting physical measurement, observation, sampling and analytical investigation of environmental parameters and resources to establish existing/current situation or baseline conditions.

Linkage with the 70,000 DWT Affiliated Coal Handling Terminal

An Affiliated 70,000 DWT Coal Handling Terminal (CHT) would be developed purposefully to meet the specific development and operational requirements of the 2X350 MW Supercritical Coal-fired Power Plant. Consequently, the development and operation of the CHT would be directly linked to the development and operation of the Power Plant. The two projects would be situation within the same location and therefore co-exist within the same environment with coinciding area of influence. Similarly, the environmental and social impact and implications would be significantly linked cumulatively; hence mitigation measures and environmental management initiatives may be common to the two projects.

Structure of ESIA Report

The ESIA Report is structured as follows:

Chapter 2: Policy, Legal & Administrative Framework: outlines the combination of relevant policies, legislative and administrative framework within the context for ESIA. It also covers the international protocols, conventions and legal requirements for the projects; specifically, those of IFC, World Bank Group, and China Banking Regulation Commission. Furthermore, the chapter illustrates the corporate standards, programmes and best practices applicable to the project.

Chapter 3: Description of the Undertaking: provides a reasonably detailed description of the project including the background to the development of the project, project location, scale and scope of the project design, construction and operation, manpower and materials requirements for the various stages of the project and their sources and project schedule as well as financial requirements.

Chapter 4: Consideration of Alternatives: describes all alternative and subsequent designs options and site considerations reviewed and also in relation to cost benefit analysis and environmental concerns and implications. Also the issues would cover consideration of the alternative situation where the undertaking is not proceeded with.

Chapter 5: Baseline Information: provides detailed description of the resources and environmental situation of the proposed site including the immediate adjoining land uses and zoning status. Further provides detailed description of the existing environment (including the physical, biological, socio-cultural and economic) of the project area.

Chapter 6: Consultations: presents the findings of all the consultations and engagements in relation to informing all stakeholders to be affected by the project, including the state agencies, District Assemblies and local communities and individuals etc. The dialogue covered the various issues of concern in relation to the potential impact of the project and the mitigation proposals to alleviate potential impact.

Chapter 7: Identification, Analysis and Evaluation of Impacts: provides detailed description of the potential impacts of the proposed the development including the methodology used for the impacts identification. Information on potential, positive and negative impacts of the proposed undertaking from the environmental, social, economic and cultural aspect in relation to the different phases of the development of the undertaking is provided. The identified impacts are described in terms of their nature, duration, magnitude, areal extent and frequency and categorized into all the phases of the project, particularly Pre-constructional, Constructional, Operational and Decommissioning Phases of the project.

Chapter 8: Mitigation Measures: presents the description of the proposed mitigation measures from the pre-construction, construction, operational and decommissioning activities; and outlines the details of the specific mitigation options and considerations against the identified significant impacts, defined in terms of costs, manpower, equipment and technology needs.

Chapter 9: Monitoring Plan: presents the periodic measures put in place to observe any significant deviations from the baseline conditions of the environment and particularly the identified receptors; described to cover constructional activities, operational and decommissioning activities of the project.

Chapter 10: Environmental Management Plan: describes the provisional Environmental Management Plan (EMP) developed to minimize the potential environmental impacts due to proposed project. It also presents the commitment of the proponent to ensure adequate safeguard of the environment as well as the surrounding population.

Chapter 11: Decommissioning: describes the activities to remove the installed facilities and equipment and return the site to a condition as close to a pre-construction state as feasible to ensure public health and safety, environmental protection, and compliance with applicable regulations. It further outlines the procedures and activities for reclamation during and after completion of project operation as well as measures to be taken to prevent unnecessary or undue degradation.

Chapter 12: Conclusions & Recommendations: outlines the general overview of all conclusions arrived at during the study and recommendations made in order to justify the issuance of an Environmental permit.

Chapter 13: References: outlines the list of references used for the analytical review and in the preparation of the report.

Appendices

2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

This chapter outlines the national and international institutional legislations, administration, standards and guidelines relevant to the project ESIA, including international treaties, conventions and relevant corporate policies.

Specifically, the chapter provides the relevant information in relation to the following:

a) Ghana's Government and Administrative Framework;
b) Ghana's environmental and social laws and regulations deemed applicable to the Project;
c) International conventions, standards and guidelines, which the Project will comply with and;
d) The corporate policies of the financing institution China Africa Development Fund (CAD) and the proponents both the SEC and VRA.

2.1 Government and Administrative Framework

2.1.1 The Ghanaian Constitution

Article 41(k) of the Constitution of Ghana requires that all citizens protect and safeguard the natural environment of the Republic of Ghana. As such SEC and VRA will do everything possible to safeguard the environment while pursuing their objectives.

2.1.2 Ministries and Administrative Bodies

Ghana's legislation is issued at the national level through Policies, Acts, Regulations and Guidelines. These are enforced by a number of Ministries and administrative agencies of the Ministries. The key Ministries and administrative agencies relevant to the project include:

a) Ministry of Energy; the Ministry is responsible for providing and enacting policies for the power, energy and petroleum sectors of the economy. The Ministry formulates, implements, monitors and evaluates the sector policies. The Ministry works with other stakeholders to enact policies and regulations, which provide support to stakeholders in the sectors. The relevant agencies, which work under the Ministry to promote energy generation, include the VRA, Electricity Company of Ghana and Energy Commission.

b) Ministry of Lands and Natural Resources; the Ministry is responsible for enacting land policies and leading other agencies under it to implement land related policies for the country. There are various agencies under this Ministry which include Lands Commission and Forestry Commission amongst others.

c) Ministry of Sanitation and Water Resources; the Ministry is responsible for ensuring efficiency of the sector in the initiation, formulation, implementation and co-ordination of policies and programmes for the systematic development of the country's infrastructure requirements in respect of Water Supply and Sanitation, Hydrology and Flood Control Systems. The relevant agencies under this Ministry include Water Resource Commission, Ghana Water Company Limited and Community Water and Sanitation Agencies.

d) Ministry of Defence; this Ministry is responsible for the security of the country against external attacks. The Ministry is also engaged in other humanitarian activities for the nation.

e) Ministry of Environment, Science, Technology and Innovation; the Ministry has responsibilities for the environment, settlement planning, science research and innovation. Its relevant agency is Environmental Protection Agency (EPA).

f) Ministry of Local Government & Rural Development; under this Ministry, local governance relating to the Metropolitan, Municipal and District Assemblies are regulated. Government enacts legislations and administrative policies through this Ministry.

g) Ministry of Food and Agriculture; Regulates and enacts policies under the food sector which includes fishing.

h) Environmental Protection Agency; the Agency has been established to co-manage, protect and enhance the country's environment in particular, as well as seek common solutions to global environmental problems.

i) Energy Commission; the Commission is responsible for regulation, management, development and utilization of energy resources in Ghana. The Commission further provides technical regulation of electricity, natural gas and renewable energy industries in Ghana.

j) Lands Commission; the commission is mandated to ensuring lands in the country are properly registered and protected through the land registration system. The commission also makes recommendation to Government to enact various policies responsible for the protection of the country.

k) Forestry Commission; is responsible for the regulation and utilization of forest and wildlife resources, conservation and management of the resources. It also has the responsibilities for the coordination of policies related to the protection, management and regulation of the forest and wildlife resources.

l) Fisheries Commission; is mandated to regulate and manage utilization of the fishery resources of Ghana and coordinate the related polices for promoting and enforcing policies related to fishing and fishery resources management.

m) Water Resources Commission; this is a Commission under the Ministry of Sanitation and Water Resources with the mandate to regulate and manage the water resources in Ghana. The Commission is further to promote and coordinate Government policies related to the country's water resources.

n) Minerals Commission; The Commission is the main promotional and regulatory body of the mineral sector in Ghana and is responsible for the regulation and management of the utilization of the mineral resources of Ghana and the coordination and implementation of policies relating to mining. It also has the responsibility of monitoring effectively to ensuring compliance with the Mining and Mineral laws and regulation in Ghana.

o) Ghana Ports and Harbours Authority (GPHA); the Authorityis mandated to build, operate, maintain and regulate seaports in Ghana. The Authority intents to strengthen collaboration with the private sector in ensuring improved efficiency and productivity of the entire port service delivery.

p) Ghana Maritime Authority (GMA); The Authority is charged with the responsibility of monitoring, regulating and coordinating activities in the maritime industry.

q) The Ghana Investment Promotion Centre (GIPC); the Centre is mandated with responsibility of promoting, encouraging, coordinating and monitoring all investment activities and facilitating investments. The Centre further provides for the creating of attractive incentive framework and transparent environment for investments in Ghana.

r) Ghana Grid Company Limited (GRIDCo); The Company is responsible for the establishment and exclusive operation of the national interconnected transmission system. The company functions to undertake economic dispatch and transmission of electricity from wholesale suppliers to bulk customers; and carry out transmission system planning and implementation of necessary investments to provide the capacity to transmit power and manage the wholesale power market reliably.

2.1.3 Environmental Protection Legislation

In 1991, the National Environmental Policy (NEP) was adopted by the Ghanaian Government as a means of ensuring economic development without disservices to social and environmental development. The NEP provided a framework for the implementation of the National Environmental Action Plan (NEAP) as well as a number of other policies relating to conservation and environmental management.

The Environmental Protection Agency Act

The Environmental Protection Agency Act 1994 (Act 490), is an Act of the Parliament of Ghana giving the Agency the responsibilities to formulate environmental policies, issue environmental permits and pollution abatement notices and prescribing standards and guidelines related to the pollution of air, water, land and any other environmental receptor. The Act further mandates the Agency to prescribe standards and guidelines related to discharge of waste, control of toxic substances and act to coordinate in collaboration with governmental bodies to control pollution and generally protect the environment.

The Act is in four parts; the first part establishes the Agency and its mandates, prescribing the functions and structure of the agency, including ministerial responsibilities and the governing board. The second part describes the enforcement and control mandate, defining the power of the Agency to require an environmental impact assessment for undertakings likely to impact on the environmental standards. The Agency is also mandated to require mitigation measures in respect of adverse environmental impacts of any undertaking or halt the development. Infringement of enforcement notices of the Agency is an offense liable to fine or imprisonment. The Act also mandates the Agency to appoint and authorize Environment Protection Inspectors to enter premises and ensure compliance with the laws pertaining to protection of environment. The third part relates to funding of the Agency whiles the last part prescribes the administrative functions and the general provisions.

EPA is therefore mandated to prescribe standards and guidelines and require an environmental impact assessment for undertaking the development and operation of 2X350MW Supercritical Coal-fired Power Plant at Ekumfi in the Central Region.

Environmental Impact Assessment Regulations

The ESIA process is legislated through the Environmental Assessment Regulations (LI 1652, 1999). The ESIA Regulations require that all activities likely to have an adverse effect on the environment must be subjected to environmental assessment and issuance of a permit before commencement of the activity.

The Regulations are structured in three parts. The first part defines the requirements and steps for EIA process for an environmental permit in relation to the activities of existing undertakings and new undertakings. The process starts with screening, evaluating applications in relation to location, size, land use, technology and possible output as well as the concerns of the general public.

The second part of the Regulations describes the requirements of preliminary environmental report and environmental impact statement. A scoping report outlining the scope of the proposed undertaking and the terms of reference shall be submitted prior to environmental impact statement. Public hearing and submission of the environmental impact statement shall follow and an environmental permit valid for 18 months is issued. The environmental permit shall be renewed within 24 months of the commencement of the activity following submission of environmental management plan to the Agency and revision in every three years. The format of the environmental management plan shall be determined by the Agency.

The Regulations require the persons to submit annual environmental reports in respect of the undertaking to the Agency starting from the end of the first year of the commencement of the activity.

The ESIA Regulations has set out the requirements for Preliminary Environmental Assessments (PEAs), Environmental Impact Assessments (EIAs), Environmental Impact Statement (EIS) (also termed the ESIA Report), Environmental Management Plans (EMPs) and Environmental Permitting. Schedules 1 and 2 of the Regulations provide lists of activities for which an environmental permit is required and ESIA is mandatory, respectively.

The project would be expected to follow prescribed EIA process and permitting conditions as set by the EIA Regulations and schedules 1 and 2 of the regulation, which provides list of activities for which an environmental permit is required and EIA (also termed ESIA) is mandatory.

The construction of the 2×350 MW Supercritical Coal-Fired Power Plant is an undertaking which requires a full ESIA before a permit could be issued.

Fees and Charges

Fees and Charges (Amendment) Instrument 2015, LI 2228 provides revision of the Fees and Charges applied for granting Environmental Permit by EPA. The relevant two principal fees and charges are the Processing Fee and the Permit Fee. Both are structured on the basis of the sector and scale of potential impact of the project. Other Fees and Charges include penalties levied for non-compliance with the regulations.

The Project would be required to pay for the Processing and Permit Fees to obtain the environmental permit.

Environmental Guidelines

The EPA has issued formal guidance on regulatory requirements and the ESIA process. The following documents are relevant to the ESIA process and the Project and will comply with them as required:

a) Environmental Assessment in Ghana, a Guide to Environmental Impact Assessment Procedures (EPA, 1996).
b) Regulations 11 to 13 of the LI 1652 set out the scope and the extent of the EIA being prepared. Environmental Quality Guidelines for Ambient Air (EPA).
c) Sector Specific Effluent Quality Guidelines for Discharges into Natural Water Bodies (EPA).
d) General Environmental Quality Standards for Industrial or Facility Effluents, Air Quality and Noise Levels (EPA).
e) Fees and Charges Amendment Act, LI 2228. This provides information on the fees charged by the EPA passed into law by the Parliament of Ghana in 2015.
f) National Climate Change Policy adopted in 2013 by the Ministry of Environment Science Technology and Innovation (MESTI). This policy aims at strengthening measures to reduce greenhouse gas emissions (direct and fugitive emissions), mainly from the energy sources (including power generation, oil and gas, transport, biomass), industry, and waste sectors.

2.1.4 Resource Management and Pollution Legislation

Land Legislations

The legislations regulating land acquisition and compensation settlements include:

a) The State Lands Act, 1962
b) The Lands (Statutory Wayleaves) Act, 1963
c) The Land Planning and Soil Conservation Act, 1953 (Act 32)
d) The Lands Commission Act, 1994 (Act. 483)
e) The Stool Lands Act, 1994 (Act 481)
f) The Ghana Land Policy, 1999

SEC and VRA will acquire significant portions of land for the thermal project. The acquisition of these lands as well as compensation shall be governed by three key legislations including the State Lands Acts, the Stool Lands Acts and the Land Commission Acts.

The State Lands Act, 1962 (Act 125) and its amendments establish the principles for compulsory acquisition of land. After the submission of an application to acquire land, a "Site Advisory Committee" is set up in order to assess the application. The application is then assessed and recommendation given to the Land Commission, which prepares an executive instrument. Once this instrument is accepted and endorsed by the Minister, it is published in the newspapers and claims can be submitted by property owners. The valuation board estimates the corresponding compensation. Compensation is then made to the property owners and sometimes resettlement is followed.

The Stool Lands Act, 1994 (Act 481). Stool lands are defined as that which belongs to or is controlled by a stool or skin, the head of a particular community/ family, for the benefit of the subjects of that stool or the members of that community.

The Lands Commission Act, 1994 (Act 483) details the management framework for public and other lands and establishes a commission to assist and advise the government, local and traditional authorities on land related issues, usage and management concerns. The Act establishes the Land Commission under the Ministry Lands and Natural Resources to oversee all Land issues.

The Commission comprises four divisions:

a) Land Registration Division (formerly Land Title Registry and the Deeds Registry)
b) Land Valuation Division (formerly Land Valuation Board)

c) Survey and Mapping Division (formerly Survey Department) and
d) Public and Vested Lands Management Division (formerly Lands Commission) (Commonwealth of Nations, 2012).

The Land Commission governs land acquisitions, as would be required for the Project.

Water Resources Legislations

Water resources in Ghana are governed by two pieces of legislation, namely the Water Resources Commission Act (Act 52 of 1996) and the Water and Sewerage Corporation Act (Act 310 of 1965).

For the purpose of the proposed project, the Water Resources Commission Act (Act 52 of 1996) is relevant here. The Act establishes the Water Resources Commission to regulate and manage the use of water resources of Ghana. The Act defines the composition of the Board as well as its functions. According to the Act, water resources cannot be used without authority except for firefighting; however, water resources may be used for domestic purposes. The Act prohibits the construction for the purpose of water abstraction without authorization. Water use right may be obtained by application made to the Commission. The Commission publishes gazette notice of applications. Any person claiming could be affected from the grant for water use may object to the Commission within three months of the gazette notice. The failure of the user to comply with conditions of the grant of water use and to remedy the default within the period specified by a written notice, the water use grant is terminated.

The Commission is tasked with establishing comprehensive plans for the use, conservation, protection, development and improvement of Ghana's water resources and is able to grant water rights for the exploitation of water resources.

Biodiversity and Wildlife Legislations

The project would utilize biologically rich forest, riverine and marine environments, legislations that govern these environments will be strictly adhered to by the SEC and VRA.

The legislations which regulate biodiversity and wildlife in Ghana are:

a) Wild Animals Preservation Act, Act 235 1964

b) Wildlife Conservation Regulations 1971 (LI 685)
c) Wild Reserves Regulations 1971 (LI 740)
d) The Wetland Management Regulation, 1999
e) Forest Protection (Amendment) Act 2002, Act 624
f) Fisheries Act 2002, Act 625

Wild Animals Preservation Act, 1961 (Act 43) provides to consolidate and amend the law relating to wild animals, birds and fish and to continue the observance of the convention signed at London on the nineteenth day of May 1900. The Minister may appoint honorary game officers to carry out all or any of the purposes of this Actor do anything required or allowed by this Act to be done by a game officer. The Act mandates the Minister to permit the collection of specimens of animals for scientific purposes; and restricts export and import of trophies. A person shall not export any trophy from Ghana unless granted a certificate by a Superior Police Officer not below the rank of Assistant Superintendent. Section 5 relates the marking and identification of trophies consisting of ivory. Section 6 relates to prohibition of hunting by motor-vehicle or aircraft. Section 7 relates to prohibition of surrounding animals by fires. Section 8 describes the powers of Game Officers to arrest persons without a warrant. Trophies of animals shot by a Game Officer in the execution of his/her duty shall be the property of the Government. Section 11 defines regulation making powers of the President for purposes of administration (Food and Agriculture Organization of the United Nations). Annexes I and II list those species protected by law.

The Wetlands Management Regulations, 1999 establishes wetlands ("Ramsar sites") for purposes of the Convention of Wetlands of International Importance especially as Waterfowl Habitat and assigns specified powers to the Minister responsible for lands and forestry, the Director of the Wildlife Division of the Forestry Commission, and District Assemblies in respect of such sites. The Regulations describe activities that are prohibited or restricted in the sites. The Minister may also declare closed seasons during which certain activities including fishing are prohibited. A District Assembly where a Ramsar Site is located may, in consultation with the Minister and by Bye-law, prescribe custody and traditional conservation practices which are compatible with the Ramsar Convention and permitted under these Regulations (FAO, IUCN and UNEP, no date).

Fisheries Act, 2002 (Act 625) mandates the establishment and administration of the fisheries commission as well as financial provisions. The Act regulates fisheries management and development and includes provisions related to fishing vessels, aquaculture and recreational fishing, licensing of fishing vessels. The Act also contains provisions for establishment of fishing zones, methods, seasons for fishing, and conservation measures. It stipulates provisions for monitoring, control, and surveillance. Section 93 of the Fisheries Act requires that the Fisheries Commission is informed of any activity with potential impacts on fishery resources and provided with mitigation strategies by proponents of the project. This is particularly important due to the services (food, income and employment) provided by the resource.

Pollution Control

Pollution Control is defined through the existing environmental legislations, rather than a single overarching framework. These will be adhered to during all phases of the project and include:

a) Section 2(f) of the Environmental Protection Act (1994) which empowers the EPA to issue abatement notices for pollution regulation.
b) Section 2(h) and 2(j) of the Act further enables the EPA to administer guidelines on environmental pollution and to collaborate with other bodies such as District Assemblies in controlling pollution respectively.
c) In addition, Section 24 of the The Water Resources Commission Act prohibits polluting water resources.

The project would utilize forest, riverine and marine environmental resources; legislations that govern these environments will be strictly adhered to by the SEC and VRA.

2.1.5 Energy Legislation

The Ministry of Energy is the highest executive body responsible for formulating, monitoring and evaluating policies, programmes and projects in Ghana's energy sector. There are other public Agencies working to support the activities of the Ministry of Energy. These public Agencies regulating the energy sector include:

a) The Energy Commission established by the Energy Commission Act (Act 541) is responsible for making policy recommendations to the Government to regulate the development and utilization of energy resources sector in Ghana. The Commission institutes rules, standards and procedures as well as grants licenses for generation, transmission, wholesale supply and distribution of electricity. The Commission has an Inspectorate Division to inspect premises to ensure that the provisions of the act are complied with.

b) There are two subsidiary regulations established to provide proper management of the energy sector in Ghana. The first is the Electricity Transmission (Technical, Operational and Standards of Performance), 2008. Its objective is to establish the requirements, procedures, practices and standards that govern the development, operation, maintenance, and use of the high voltage national interconnected transmission system. The second regulation is the Electricity Regulation, 2008 which provides the planning, reliability, general safety, and overall regulation of the electricity market.

c) The National Electricity Grid Code, 2009 is designed to guide and regulate the activities of electricity transmission utilities and independent system operators in order to facilitate competition in power generation. It was established by the Commission and describes the requirements, procedures, practices and standards of the National Interconnected Transmission System (NITS) in Ghana. Furthermore, the Code ensures that the distribution network provides fair, transparent, non-discriminatory, safe, reliable, secure, and cost efficient delivery of electrical energy.

d) The Public Utility Regulatory Commission responsible for regulating utility tariffs in the country. The Public Utility Regulatory Commission (PURC) is responsible for regulating utility tariffs in the country; Public Utility and Regulatory Commission Act (Act 538), 1997.

The Commission is the body with oversight responsibilities for the provision of the highest quality of electricity and water services to consumers.

The objectives of PURC include:

- Providing guidelines for rates to be charged for the provision of utility services;
- Examining and approving electricity and water rates;
- Protecting the interest of consumers
- Monitoring and enforcing standards of performance for the provision of utilities services;
- Promotion of fair competition among public utilities
- Receiving and investigating complaints and settling disputes between consumers and public utility;
- Advising any person or authority in respect of any public utility

There are also public utility Agencies operating under the Ministry of Power. They are also responsible for generation, transmission and distribution of power or electricity in Ghana. These are;

a) Volta River Authority
b) Bui Power Authority
c) Ghana Grid Company
d) Electricity Company of Ghana

The National Electrification Scheme is a notable programme with the aim of extending electricity to all communities in Ghana. For achieving this, the National Energy Policy, 2000 developed by the Energy Commission has included a section on the expansion of electricity production as well as its distribution and transmission.

Relating to this the Government to Ghana has been pursuing the following in regards to thermal plants:

a) Financing from the private sector for the rehabilitation and expansion of existing power plants;
b) Completing the construction of on-going power projects;
c) Encouragement of private sector investment in the construction and ownership of additional power plants.

Electricity generation is undertaken by the state-owned Volta River Authority (VRA) and the Bui Power Authority (BPA).

Regulations governing the supply and transmission of electricity include:

a) The Public Utilities Regulatory Commission (PURC), Act 538 (1997)
b) Electricity Transmission (Technical, Operation and Standards of Performance) Rules. 2008 L.I. 1934 and
c) L.I. 1937: Electricity Regulations, 2008

The project would generate, transmit and supply electricity to Ghana at an agreed tariff in accordance to the energy legislative and regulatory requirements of Ghana.

2.1.6 Maritime Legislation

The GMA superintends over the Ghana Maritime Authority Security Act 2004 (Act 675) gives effect to Chapter XI-2 of the International Convention for the

Safety of Life at Sea 1974 (Solas) as amended to enhance maritime safety and security.

The Act seeks to implement the International Ship and Port Facility Security (ISPS) Code to enhance the safety and security of ships and port facilities. The ISPS code was developed by the international maritime community to provide a system for securing maritime terminal.

Consequently, the ports of Tema and Takoradi are issued documents of compliance and thereby created positive environment for ships to call at the ports.

The Act provides for Ghana Maritime Authority additional mandate and role of recognized security organizations in relation to security levels for ships and port facilities; furthermore, providing for security level and security level information for ships and port facilities.

Again, the Act provides for ship security plan and international security certification for Ghanaian ships as well as requirements in relation to International Ship Security Certificate and Security Level for all ships intending to enter Ghanaian ports.

Ghana Shipping Act, 2003 (Act 645) (as amended) provides rules for shipping and related matters such as survey, registration, licensing and marking of ships, mortgages on ships, maritime liens and claims, ship records, prevention from collisions and maritime security, construction and importation of ships, carriage of dangerous goods, (limitation of) liability and divisions of liability and protection of the marine environment. The GMA shall be the principal administrative authority of purpose of this Act. Extensive regulation-making powers are granted to the Minister. The Act contains provisions on the marking of fishing vessels and exempts fishing vessels from various provisions regarding, among other things, maritime security and load lines. The Act defines powers of the Authority for purposes of protecting the marine environment.

The project would develop its dedicated port facilities, which would be required to operation in compliance with the international and national maritime regulations to ensure maritime security and safety for the ships and port facilities.

2.1.7 Other Relevant Ghanaian Regulations

There are other relevant legislations which are applicable to the project and include as follows;

a) *Factories, Offices and Shops (Amendment) Law, 1983 (PNDCL 66)*
Section 3 part 1 of the Factories, Offices and Shops Law states that not less than one month before someone begins to occupy or use the premises as a factory, must apply for the registration of the premises by sending to the Chief Inspector a notice containing the particulars set out in the First Schedule.

b) Ghana National Fire Service Act, 1997 (Act 537), s.33(b)
The Ghana National Fire Service is established in accordance with article 190 of the constitution and with the objective to prevent and manage undesired fire.

The functions of the service for the purpose of achieving its objectives include:

1. Organize public fire education programmes to create and sustain awareness of the hazards of fire, and heighten the role of the individual in the prevention of fire;
2. Provide technical advice for building plans in respect of machinery and structural layouts to facilitate escape from fire, rescue operations and fire management;
3. Inspect and offer technical advice on fire extinguishers;
4. Co-ordinate and advise on the training of personnel in firefighting departments of institutions in the country;
5. Train and organize fire volunteer squads at community level;
6. Offer rescue and evacuation services to those trapped by fire or in any other emergency situations, and
7. Undertake any other function incidental to the objective of the Service.

c) Labour Act 2009 Act 651;
The Act 651 provides protection of employment for employees, fair and unfair termination of employment, protection of remuneration, special provision for both temporary and casual workers among others.

d) Local Government Act 462 1993;
Under the planning functions of the district assemblies for the development charges, the District Assembly may levy development charge in respect of a planning permit granted for the carrying out of a physical development.

e) National Building Regulation, 1996 (LI 1630)
The National Building Regulation (NBR) (L.I. 1630) was enacted in 1996 in Ghana to regulate the erection of buildings, alteration of building structures and execute works or install fittings in connection with any building.

f) *Town and Country Planning Ordinance, 1945 (Cap 84)*:

The Town and Country Planning Department (TCPD) was established in pursuant to the Town and Country Planning Ordinance (Cap 84) and charged with the responsibility of planning and managing the growth and development of cities, towns and villages in the country.

It therefore seeks to promote sustainable human settlements development based on principles of efficiency, orderliness, safety and healthy growth of communities. It also coordinates the diverse/various types of uses and development of land undertaken by various departments and agencies of government as well as private developers.

Other legislative instrument which backs the establishment of the department includes:

- Local Government Act, 1993 (Act 462)
- National Development Planning Commission (NDPC) Act, 1994 (Act 479)
- National Development Planning (System) Act, 1994 (Act 480)
- National Building Regulations, 1996 (LI 1630)

g) The Children's Act (Act 560) of 1998

An ACT to provide for the rights of the child, maintenance and adoption, regulate child labour and apprenticeship, for ancillary matters concerning children generally and to provide for related matters.

For purposes of this Act, a child is a person below the age of eighteen years. Part V. of the Act relates to the employment of children and child labour. The act stipulates that:

- No person shall engage a child in exploitative labour.
- No person shall engage a child in night work.
- The minimum age for admission of a child to employment shall be fifteen years.
- The minimum age for the engagement of a child in light work shall be thirteen years.
- The minimum age for the engagement of a person in hazardous work is eighteen years.
- An employer in an industrial undertaking shall keep a register of the children and young persons employed by him and of the dates of their

births if known or of their apparent ages if their dates of birth are not known.

2.1.8 Relevance of Legal and Regulatory Framework

The relevance of these legal and regulatory framework mentioned above to the Project has been concluded in ***Table 2-1***.

Table 2-1 The Relevance of the Legal and Regulatory Framework to the Project

No.	Legal and Regulatory Framework	Summary of Core Requirements	Relevance to the Project
1	The Ghanaian Constitution	Requires the proponents to protect the natural environment and resources of the country	Demand on the Project to demonstrate good stewardship in relation to national environmental resources.
2	Environmental Protection Agency Act, 1994	• Requires an environmental impact assessment for undertakings likely to impact on the environmental standards. • Requires mitigation measures in respect of adverse environmental impacts of any undertaking or halt the development	Relates to the requirements of Project to comply with the regulatory and permitting requirement, abatement notices and prescribed standards and guideline on pollution of air, water, land and any other environmental receptor by EPA.
3	Environmental Impact Assessment Regulations (LI 1652), 1999	• Conduct environmental impact assessment and securing environmental permit before commencement of the activity • Procedural framework for environmental impact assessment and permitting • Submission of EMP and renewal of permit within 24 months of commencement of activity and revision every 3 years • Submission of annual environmental report after the first year of activities. • Processing and Permit Fees are charged and Penalties levied for non-compliance with the regulation.	Relates to the requirements of the project to conform to environmental assessment processes, reporting and issuance of permit before commencement of project development activities. Further, the regulation demands the Project to submit annual environmental reports to the EPA.
4	Water Resources Commission Act (ACT 52), 1996	Water use right should be obtained as authorization for construction for abstraction of water.	Requires that the Project apply for authorization for water abstraction and use right from the commission.
5	Wild Animals Preservation Act, (ACT43) 1961	• Adherence to biodiversity and wildlife conservation regulation in Ghana; Conservation of protected species.	Relates to the requirements of the project to comply with protection of animal species identified in Annexes I and II of the ACT.
6	Wetland Management Regulation, 1999	Restriction/prohibition of activities in wetlands	Requires the project to comply with prohibition of activities within Wetland
7	Fisheries Act (ACT 625) 2002	• Protection of fishing zones; Inform the Fisheries Commission of activities of	Relates to the requirements of the project to duly notify the Fisheries Commission of any

No.	Legal and Regulatory Framework	Summary of Core Requirements	Relevance to the Project
		the project with the potential impact on fisheries resources.	activities, which may have potential impact on fisheries resources and further provide mitigation strategies by the Project.
8	Energy Commission Act (ACT 541)	• Conformity with the rules, standards and procedures for development and utilization of energy resources; • Secure licence for generation, transmission and wholesale supply of electricity;	Relates to the requirements of the project to conform to the rules, standards and procedures; and meeting the Technical Operational and Standards of performance stipulated by the commission. Furthermore obtain licenses for generation, transmission and wholesale supply of electricity.
9	Public Utility Regulatory Commission Act (ACT 538), 1997	• Conform to electricity tariff guidelines; • Conform to quality standards for provision of electricity.	Provision of guideline for rates to be charged for the provision of utility services
10	Ghana Maritime Authority Security Act, (ACT 675) 2004	• Conform to international ship and port facility security; • Secure documents of compliance with port facility security for the terminal; • Conform to security level procedures and security level information for ships and port facilities	Requires the Project to comply with International Ship and Port Security (ISPS) Code to enhance the safety and security of ships and port facilities. The Project is to be issued with document of compliance, which ensures creation and maintenance of positive environment for ships to call at the ports.
11	Factories, Offices and Shops (Amendment) Law, 1983 (PNDCL 66)	• Provide required particulars to Factories Inspectorate Directorate • Registration of premises as factory	Requires the Project to secure registration of the premises not less than one month before commencement of occupation or use the premises as a factory.
12	Ghana National Fire Service Act, 1997 (Act 537); S 33b	• Provide fire-fighting facilities at the premises; • Obtain fire certificate for the premises • Undertake periodic fire education and awareness campaign	Relates to sections 31, 32 and 33 of the Factories, Offices and Shops Act, 1970 (Act 328) regarding fire prevention and safety in a factory, office or shop and provision technical advice for building plans and issuance of fire clearance certificate. Furthermore, relating to building and sustaining awareness and competences in management of hazards of fire, and heighten

No.	Legal and Regulatory Framework	Summary of Core Requirements	Relevance to the Project
			the role of the individual in the prevention of fire;
13	Labour Act 2009 Act 651	Comply with labour regulations	Relates to compliance with protection of employment for employees, fair and unfair termination of employment, protection of remuneration, special provision for both temporary and casual workers among others.
14	Local Government Act 462 1993	Acquire development permit Payment of development charges	Relates to the acquisition of development permit and payment of development charges under the planning functions of the district assemblies.
15	National Building Regulation, 1996 (LI 1630)	Comply with National Building Regulations	Relates to the requirements regulating the erection of buildings, alteration of building structures and execute works or install fittings in connection with any building.
16	Town and Country Planning Ordinance, 1945 (Cap 84)	Conformity to land use zoning and development planning	Relates to the requirements to conform to the development planning and land use zoning of the village.
17	The Children's Act (Act 560) of 1998	Compliance with child labour regulation; prohibiting exploitative child labour.	Relates to employment of children and child labour; prohibiting exploitative child labour and child labour at night, and stipulates the minimum age for child labour, light work and hazardous employment and also registration of children and young persons in industrial undertaking.

2.2 Relevant International Agreements and Conventions

Ghana is signatory to a number of international conventions and agreements and regional treaties seeking to conserve key ecosystems and natural resources and in relation to energy development, and environmental management (See ***Table 2-2***).

In certain case conventions and agreements have influenced policy, guidelines and regulations and must be considered in the impact assessment and complied with during the planning, construction and operation of this project. Also these agreements are cited in the World Bank's key international agreements on the environment.

Table 2-2 Relevant International Agreements and Conventions

International Agreements and Conventions	**Year Ratified**
The International Labour Organisation (ILO) Fundamental Conventions related to forced labour, freedom of association, discrimination and child labour.	2011
International Covenant on Economic, Social and Cultural Rights	2000
Gulf of Guinea Large Marine Ecosystem Project	1999
Memorandum of Understanding Concerning Conservation Measures for Marine Turtles of Atlantic Coast of Africa	1999
United Nations (UN) Convention on Biological Diversity	1994
Framework Convention on Climate Change	1992
Convention of Fisheries Cooperation among African States Bordering the Atlantic Ocean	1991
African Charter on Human and Peoples' Rights	1989
Montreal Protocol on Substances that Deplete the Ozone Layer	1989
Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of West and Central African Region (Abidjan Convention)	1981, ratified in 1989
Convention on Wetland of International Importance (Ramsar)	1988
Convention on the Conservation of Migratory Species of Wild Animals	1988
Convention Concerning the Protection of Workers against Occupational Hazards in the Working Environment due to Air Pollution, Noise and Vibration (ILO No. 148)	1987
United Nations Convention Law of the Sea	1982
Convention on the Conservation of Migratory Species of Wild Animals	1979

International Agreements and Conventions	Year Ratified
Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention) , Paris	1975
Convention on International Trade on Endangered Species of Wild Fauna and Flora	1973
Convention on Wetlands of International Importance, Especially as Waterfowl Habitats	1971
African Convention on Conservation of Nature and Natural Resources.	1968
International Convention for the Conservation of Atlantic Tunas	1966

2.3 International Best Practice Standards and Guidelines

2.3.1 International Standards, Guidelines and Conventions

The relevant International Finance Corporation Performance Standards on Environmental and Social Sustainability document; The Environmental, Health, and Safety (EHS) Guidelines, Thermal Power Plants are the technical reference documentsfor the project and will be considered as international requirements for Good International Industry Practice (GIIP)[3]. The IFC requires the Project Company to carry out an environmental and social assessment of Project-related impacts according to the Performance Standards on Environmental and Social Sustainability. The IFC's PSs are listed as follows:

- PS1: Assessment and Management of Environmental and Social Risks and Impacts;
- PS2: Labour and Working Conditions;
- PS3: Resource Efficiency and Pollution Prevention;
- PS4: Community, Health Safety and Security;
- PS5: Land Acquisition and Involuntary Resettlement;
- PS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- PS7: Indigenous Peoples; and
- PS8: Cultural Heritage.

The following guidelines of the IFC, which are deemed relevant to the Project, to be followed during the design of the Project and the Environmental and Social Assessment study are as follows:

[3]IFC, Environmental, Health, and Safety Guidelines, Thermal Power Plants.

- The IFC General EHS Guidelines, dated April 30th, 2007;
- The IFC EHS Guidelines for Thermal Power Plants, dated December 19th, 2008;
- The IFC EHS Guidelines for Shipping, dated April 30, 2007;
- The IFC EHS Guidelines for Ports, Harbours and Terminals, dated April 30, 2007;
- The IFC EHS Guidelines for Electric Power Transmission and Distribution, dated April 30th, 2007; and
- The IFC Workers' accommodation: processes and standards, dated August 2009.

To aid decision making on provision of financing, qualification for financing, financial advisory and loans the ESIA must conform to a number of international standards. These include the IFC Performance Standards as follows:

a) Assessment and Management of Environmental and Social Risks and Impacts
b) Labour and Working Conditions
c) Resource Efficiency and Pollution Prevention
d) Community Health, Safety, and Security
e) Land Acquisition and Involuntary Resettlement
f) Biodiversity Conservation and Sustainable Management of Living Natural Resources
g) Indigenous Peoples
h) Cultural Heritage

Furthermore, the proposed project has been developed in compliance with the Equator Principles of Equator Principles Financial Institutions; consisting of the following:

a) Review and Categorisation
b) Environmental and Social Assessment
c) Applicable Environmental and Social Standards
d) Environmental and Social Management System and Equator Principles Action Plan
e) Stakeholder Engagement
f) Grievance Mechanism
g) Independent Review
h) Covenants
i) Independent Monitoring and Reporting
j) Reporting and Transparency

Compatibility with the IFC performance Standards necessitates compliance with the World Bank Group's Environmental, Health and Safety Guidelines (EHS Guidelines) under the following broad headings:

a) Environmental and Social Assessment
b) Occupational Health and Safety
c) Community Health and Safety
d) Construction and Decommissioning

Industry Specific EHS Guidelines of the project would comply with:

a) EHS Guidelines for Thermal Power Plants
b) EHS Guidelines for Electric Power Transmission and Distribution

2.3.2 International Convention for the Prevention of Pollution from Ships

The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes (International Maritime Organization, 2014).

The MARPOL Convention was adopted on 2 November 1973 at International Maritime Organization (IMO). The Protocol of 1978 was adopted in response to a spate of tanker accidents in 1976-1977. As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument entered into force on 2 October 1983. In 1997, a Protocol was adopted to amend the Convention, and a new Annex VI was added which entered into force on 19 May 2005. MARPOL has been updated by amendments through the years (International Maritime Organization, 2014).

The Convention includes regulations aimed at preventing and minimizing pollution from ships – both accidental pollution and that from routine operations – and currently includes six technical Annexes. Special Areas with strict controls on operational discharges are included in most Annexes.

Annex I: Regulations for the Prevention of Pollution by Oil (entered into force 2 October 1983): covers prevention of pollution by oil from operational measures as well as from accidental discharges; the 1992 amendments to Annex I made it mandatory for new oil tankers to have double hulls and brought in a phase-in schedule for existing tankers to fit double hulls, which was subsequently revised in 2001 and 2003.

Annex II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk (entered into force 2 October 1983): details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk; some 250 substances were evaluated and included in the list appended to the Convention; the discharge of their residues is allowed only to reception facilities until certain concentrations and conditions (which vary with the category of substances) are complied with. In any case, no discharge of residues containing noxious substances is permitted within 12 miles of the nearest land.

Annex III: Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form (entered into force 1 July 1992): contains general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications. For the purpose of this Annex, "harmful substances" are those substances which are identified as marine pollutants in the International Maritime Dangerous Goods Code (IMDG Code) or which meet the criteria in the Appendix of Annex III.

Annex IV: Prevention of Pollution by Sewage from Ships (entered into force 27 September 2003): contains requirements to control pollution of the sea by sewage; the discharge of sewage into the sea is prohibited, except when the ship has in operation an approved sewage treatment plant or when the ship is discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land; sewage which is not comminuted or disinfected has to be discharged at a distance of more than 12 nautical miles from the nearest land. In July 2011, the IMO adopted further amendments to MARPOL Annex IV which introduce further limitations to ships operating in the Baltic Sea.

Annex V: Prevention of Pollution by Garbage from Ships (entered into force 31 December 1988): deals with different types of solid waste and specifies the distances from land and the manner in which they may be disposed of; the most important feature of the Annex is the complete ban imposed on the disposal into the sea of all forms of plastics. In the last revision of Annex V in March 2012, the discharge of all garbage into the sea, except as provided otherwise in regulations 4, 5, and 6 of the Annex, which are related to food waste, cargo residues, cleaning agents and additives and animal carcasses, are prohibited.

Annex VI Prevention of Air Pollution from Ships (entered into force 19 May 2005): sets limit on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances; designated emission control areas set more stringent standards for SO_X, NO_X and particulate matter. In 2011, after extensive work and debate, the IMO adopted ground breaking mandatory technical and operational energy efficiency measures which it is hoped will significantly reduce the amount of greenhouse gas emissions from ships; these measures were included in Annex VI.

2.3.3 Green Credit Guidelines of the China Banking Regulation Commission

Moreover, the proposed project must be developed in compliance with the China Banking Regulation Commission Green Credit Guidelines to ensure complying with the Chinese Financing requirements.

The China Banking Regulation Commission issued the Green Credit Guidelines, which regulate the Banking and financial sector in China.

The Guidelines, which is in line with the implementation of policies provided for Energy Conservations and Emission reduction is based on the Banking Industry Regulation and Administration Law of the People's Republic of China and Commercial Banking Law of the People's Republic of China. The purpose of the guidelines serves to promote green credit growth among banking financial institutions.

The guideline enjoins Banks to promote green credit as a strategy, support economy to grow in a green, low-carbon and recycled model through business innovation, manage environmental and social (E&S) risks, improve banks' own E&S performances, and in doing so optimize credit structure, improve services and contribute to the transformation of economic growth pattern.

Furthermore, the guideline demands Banks to effectively identify, assess, monitor, control or mitigate E&S risks in business operations, develop E&S risk management systems, strengthen credit policies and processes that are related.

The Bank is required to put in place Lending Process Management including determined scope of E&S risk due diligence based on sectors and geographic features of the client; stringent compliance review on clients; credit approval management based on nature and severity of E&S risk faced by clients.

2.4 Project Environmental Standards

The environmental standards considered for the project include the EPA Guidelines (National Environmental Quality Guideline), IFC Environmental Health and Safety Guidelines, MARPOL Standards, and Green Credit Guideline.

The selection of standards for environmental parameters has given preference to more stringent standards and considered as the "Limit Value".

2.4.1 Ambient Air Quality

The standards for ambient air quality considered for the project have been selected from EPA guidelines for solid fuel including coal and biomass and IFC EHS guideline (See ***Table 2-3***).

Table 2-3 Environmental Standard for Ambient Air Quality

Parameter	Period (Averaging Time)	NEQG for Ambient Air Quality (μg/m³)		IFC EHS Guideline Ambient Air Quality (μg/m³)
		Industrial	Residential	Guideline Value
SO_2	1 hr	900	700	
	24 hr	150	100	150
	1 year	80	50	80
NO_2	1 hr	400	200	
	24 hr	150	60	150
	1 year	-	-	100
TSP	1 hr	-	-	
	24 hr	230	150	230
	1 year	75	60	80
PM_{10}	1 hr			
	24 hr	70	70	150
	1 year			50
Smoke	1 hr			
	24 hr	150	100	
	1 year	50	30	
CO	15 min	100 mg/m³		
	30 min		60 mg/m³	
	1 hr	30 mg/m³		
			10mg/m³	
Ozone		10 ppb		
Hydrogen Sulphide	24 hr	150		
Mercury	1 year	1		
Lead	1 year	2.5		
Fluorine	24 hr	100 mg/m³		

Source: EPA National Environmental Quality Guideline and IFC EHS Guideline

2.4.2 Air Emissions

The emission guidelines are stipulated by EPA guidelines for solid fuel including coal and biomass and IFC EHS guideline. The project standards for air emissions are accordingly specified as following: (See ***Table 2-4***).

Table 2-4 Point Source/ Stack Air Emissions Guideline

Parameter	NEQG for Emission Standards (mg/m^3)	IFC EHS Guideline For Thermal Plant (mg/m^3)	Designed Emission Contribution of the Project (mg/m^3)
SO_2	200	200 - 850	200
NOx	200	510	200
PM_{10}	50	50	50

Source: Point Source/ Stack Air Emissions Guidelines (EPA, 2016); Environmental Health and Safety Guidelines for Thermal Power Plant, IFC, December 2008

2.4.3 Noise

Table 2-5 Environmental Standard for Ambient Noise

Description of Area of Noise Reception	Permissible Noise Level in dB(A)		IFC EHS Guideline Ambient Air Quality ($\mu g/m^3$)	Selected Standard Value
	Day	Night	Guideline Value	
Residential Areas	55	48		55
Light Industrial Area	70	60		-
Heavy Industrial Areas	70	70		70

Source: EPA National Environmental Quality Guideline and IFC EHS Guideline

2.4.4 Water Quality

Table 2-6 Environmental Standard for Water Quality

Parameter	**EPA Effluent Quality Guideline for Discharges into Natural Water Bodies**
pH	6 – 9
BOD (mg/l)	50
Oil & Grease (mg/l)	5
Total Dissolved Solids (mg/l)	
Total Suspended Solids (mg/l)	50
Cadmium (mg/l)	
Total Phosphorus (mg/l)	2.0
Temperature	<3⁰C above ambient
Colour (TCU)	200
COD mg/l	250
Chromium (+6) (mg/l)	-
Sulphide (mg/l)	1.5
Turbidity (N.T.U)	75
Lead (mg/l)	0.1
Nitrate (mg/l)	50
Conductivity (µS/cm)	
Mercury	

Zinc	
Iron	

Source: EPA National Environmental Quality Guideline

2.5 Corporate Environmental Policy Statements

2.5.1 VRA Environmental Policy Statement

The Volta River Authority is committed to ensuring continuous improvement of environmental performance that minimizes potential impacts of all its operations on the environment, in line with the principles of sustainable development, in addition to complying with national and international environmental protection regulations.

In respect of the above, VRA will:

a) Make environmental considerations a priority in all business planning and decision-making and comply with relevant national and international environmental protection regulations.
b) Take reasonable steps to mitigate the impact of its actions with regard to the development, operation and management of its assets.

VRA will thus pursue the following specific objectives:

a) Develop and implement Environmental Management System for all its business units to:
b) Assess environmental impact of processes, operations and products;
c) Focus on pollution prevention and waste reduction;
d) Ensure compliance with national/ international environmental protection regulations;
e) Set annual environmental targets to ensure continuous improvements;
f) Monitor and report on environmental performance as required the appropriate stakeholders.
g) Ensure minimum environmental impact of VRA's projects and take adequate steps to mitigate any such anticipated adverse impact as far as is practicable
h) Promote environmental awareness and individual sense of responsibilities among its employees through print material for distribution, safety meetings and corporate website which will continue to be updated, and provided adequate empowerment and training for personnel to perform environmental jobs satisfactorily;
i) Support research efforts on materials, products, processes and pollution reduction techniques that are directly related to its operations;

j) Contribute to the development of public policy and programmes that enhance environmental awareness and protection;
k) Promote open communication on environmental issues
l) Undertake projects and programmes in collaboration with relevant agencies to preserve the Volta Lake resource, and reasonably restore/mitigate ecological imbalance caused by the creation of the lake;
m) Undertake projects and programmes to mitigate the impact on the livelihood of individuals and communities displaced or affected by VRA's development projects.

VRA shall design evaluation procedures for all processes for that fall under this policy to ensure that these processes comply. Deficiencies in the policy or in the evaluation procedure shall be addressed as required.

Each employee of VRA is charged to exercise his or her responsibility on behalf of VRA to ensure that the intentions of this Policy Statement are diligently carried out.

2.5.2 SEC Environmental Policy Statement

Shenzhen Energy Group Co., Ltd is committed to conducting its operations in the manner that safeguards the integrity and sustainability of the environment in conformity with the national and international environmental quality standards for sustainable development.

The policy further enjoins the company taking the necessary measures to ensure and maintain compliance with all relevant legislation on environmental protection and health and safety of all employees.

SEC commits to ensuring harmony between increased power generation and natural ecosystem conservation. At Shenzhen Energy Group Co., Ltd. all our operational activities in promoting sustainable growth in power generation are foremost guided by sustainable environmental practices and ensuring full protection of the fragile ecology.

It is our vision to use best technology in power generation whiles lowering Green House Gas emission intensity. Our key guiding principle is hinged on efficient and sustainable use of natural resources and conservation.

Management of Shenzhen Energy Group Co., Ltd. is vitally interested and committed to improving the environment and quality of life of mankind for the present and the future.

3 PROJECT DESCRIPTION

The project involves the development of an overall installed capacity of 2000MW supercritical coal-fired power plant. The development is planned in two phases identified as 2X350MW generating units developed in phase 1 and 2 units 2X350MW or 2X600MW generating units planned for the second phase of the project. The first phase of the project is planned to commence in December 2017 and be completed in 2020/ 2021.

The proponents have conducted detailed feasibility studies responding to specific external conditions and environmental demands for building power generating plant and ensuring effective and efficient technology development and optimum environmental performance.

The feasibility study, conducted by multidisciplinary team of international and local experts, assessed various aspects of the project and proposed scenarios for each process system. The aspects include (1) main equipment selection, (2) fuel supply, (3) water source, (4) Ash yard, (5) Environmental protection, (6) meteorology, (7) engineering geology, (8) transportation, (9) inter-connection systems and (10) affiliated coal handling terminal.

3.1 Land Requirements

The Project is situated at Ekumfi Aboano in the Central Region, Ghana, on parcel of land with geo coordinates 5°12'43.07"N, 0°49'52.49"W.

The conceptual design of the power plant is planned and generally arranged to optimize realization of reasonable overall planning and convenient transportation while matching with the immediate environment. Considerations have included the selection of location, transportation planning, land use planning within the site area as well as the local natural environment and other related facilities.

The site is situated between two villages and has no on–going industrial and mining activities within the area. The proposed site land area can suitably accommodate requirements for 6X350MW or 2X350MW+2X600MW coal-fired generating units with affiliated facilities including the coal handing terminal.

General layout of the plant area (See ***Figure 3-1***) covers three–column arrangement pattern, with the step-up substation area, main power house, de-sulfurization equipment and devices for coal storage and coal unloading arranged from north to south. The western area represents the fixed end and the plant area will be extended to the east. The coal handling terminal is located to the south.

Three 330KV transmission lines are planned for evacuating the power generated. Two transmission lines would be connected with the existing 330kv transmission line in the north direction with length of 15km and a third 330kv transmission line is connected to transformer substation. The power evacuation corridor is satisfied.

Figure 3-1 General Layout arranged with the western area being the fixed end while the plant area would be extended.

An ash yard is initially planned to meet the requirement for ash storage, slag and pebble coal from the operation of 2x350MW generating units for five years. The dry ash yard is proposed to be situated 1000 metres northwest of the plant site and cover an area of 53 hectares with total storage capacity of 168×10^4 m^3.

The living quarters of the plant is proposed outside the plant area arranged on the west and northwest of the plant area to meet living requirements of both the Chinese and Ghanaian staff. The living quarters would cover an area of 22.6 hectares, including the west part with an area of 14.25 hectares and northwest part of 8.35 hectares.

A general layout of the Plant Area is shown in ***Figure 3-2***. The detailed general layout of the Project is attached as in ***Appendix 1: General Layout of the Project***.

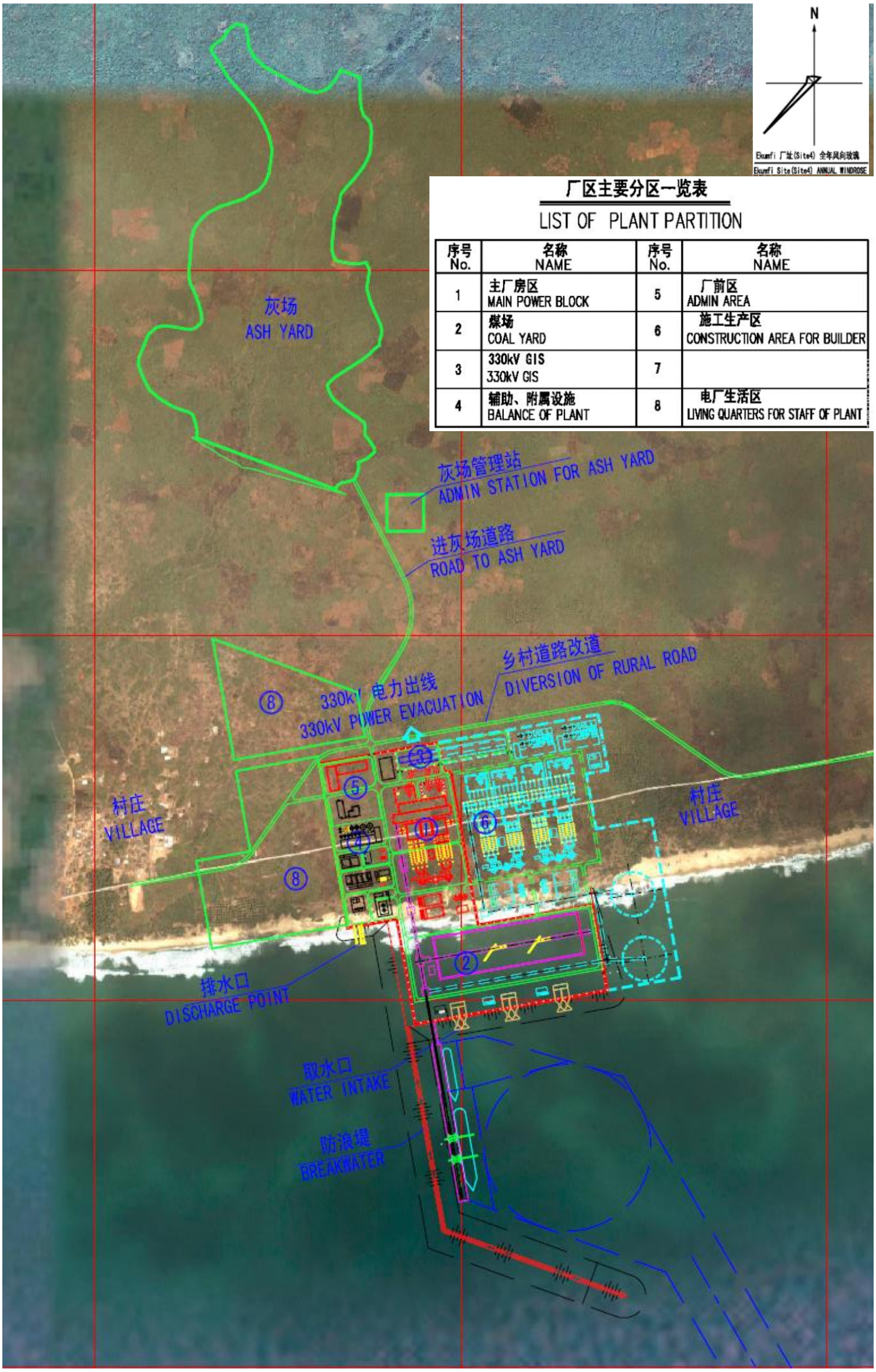


Figure 3-2 General Layout of the Project

The detailed land area of the project is presented in ***Table 3-1***.

Table 3-1 Land Area of the Project (Unit: hectares)

No.	**Land Use**	**Area**
1	Power plant (Phase I)	27.49
2	Power Plant (Phase II)	22.00
3	Road outside power plant	1.00
4	Ash yard	53.00
5	Road to ash yard	4.80
6	Construction product area	16.00
7	Living area for builders	4.00
8	Relocation of country road	14.00
9	Living quarter for staff of the power plant	8.35 14.25
10	Others	8.81
	Total	**173.70**

The Project Proponents have therefore initiated processes to acquire a total of 173.70 acre of land area for the development of project facilities including civil structures, infrastructure and installation of plant facilities. The acquisition of the parcel of land has followed due processes in accordance with national regulatory requirements. There have been extensive consultations and dialogue between the Project Proponents and the Chiefs and legitimate landowners, to ensure that the acquired parcel of land would not be encumbered with potential litigations. Survey of the land to specify boundaries and ownership have been completed. Relevant compensations have been appropriately negotiated especially in the instance where the existing landowners would be displaced demands. However, acquisition is not complete yet as purchase is not finalized.

3.2 Project Components

The power generation process produces electricity by burning coal in a boiler (steam generator) to heat water to produce steam. The steam, at tremendous pressure, flows into a turbine, which spins a generator to produce electricity. The steam is cooled, condensed back into water, and returned to the boiler to start the process over.

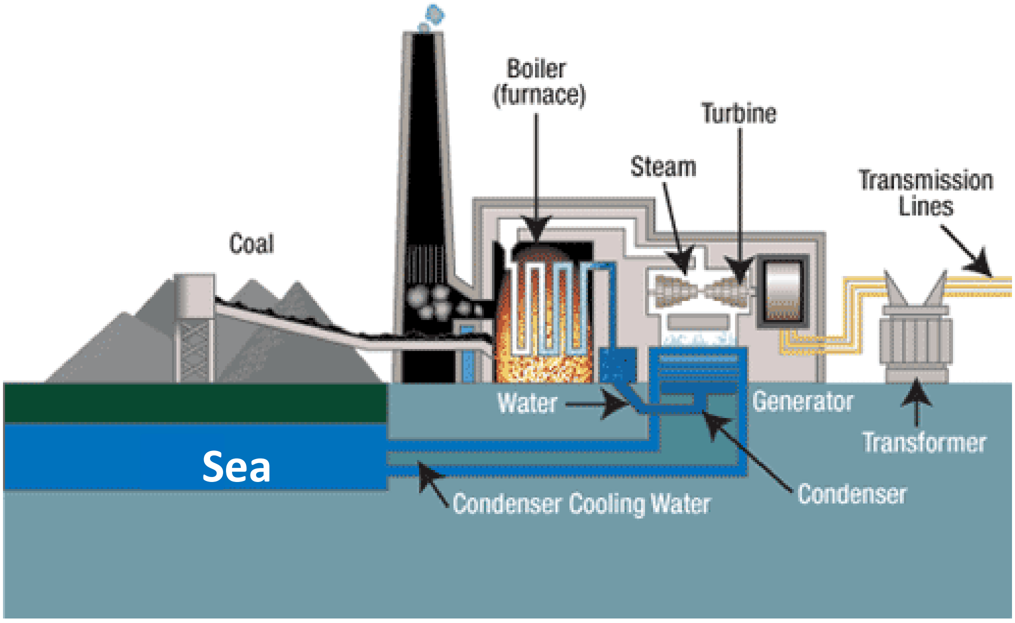


Figure 3-3 Typical Coal-fired Power Plant

The supercritical coal-fired power generating plant comprises of two power blocks each consisting of:

a) a boiler based on supercritical pulverized coal technology;
b) a steam turbine and generator unit with 350 MW rated output;
c) a once-through circulation cooling water system;
d) electrostatic precipitator for removal of dust in flue gas;
e) Seawater flue gas desulfurization for removal of SOx in the flue gas;
f) Low NOx combustion;
g) Selective catalytic reduction (SCR) for removal of NOx in the flue gas.

The main equipment and environmental protection facilities of the project are presented in ***Table 3-2***.

Table 3-2 Main Equipment and Environmental Protection Facilities

Item			Unit	Phase I Project
Capacity of Unit			MW	2x 350MW
Start of Operation			-	Year 2020
Boiler		Type	-	"π" shape Supercritical sliding operating Benson Type boiler
		Evaporative Capacity	t/h	2x 1140
Turbine		Type	-	Supercritical parameter, single reheating, two cylinders and two exhausts, single-shaft, condensing type
		Rated Output	MW	2x 350
Generator		Type	-	"Water-Hydrogen-Hydrogen" cooling type, self-shunt static excitation system
		Rated Output	MW	2x 350
Flue Gas Mitigation Equipment	Dust-removal	Type		Electrostatic Precipitator
		Efficiency	%	99.55
	Desulfuration	Type	-	Seawater Flue Gas Desulfuration
		Efficiency	%	86
	Denitration	Type		Low NOx Burner + SCR
		Efficiency		Low NOx Burner < 350mg/Nm3 SCR: 42.8%
	Stack	Type	-	Single-inner-flue-duct sleeve stack
		Height	m	180
		Inner Diameter	m	7.2
	Continuous Emission Monitoring System (CEMS)			One CEMS for One Unit
Cooling Water System		Type	-	Once-through circulation
Wastewater Treatment System	Industrial wastewater	Capacity	t/h	2x 100t/h
	Coal wastewater	Capacity	t/h	2x 20t/h
	Oily wastewater	Capacity	t/h	1x 5t/h
	Domestic	Capacity	t/h	2x 10t/h
Coal Ash Handling System		Type	-	Fly ash and bottom ash (slag) to be collected separately
		Capacity	t/a	31.63x 10^4 (Design Coal)

3.2.1 Main Thermo-Mechanical Equipment

a) Boiler

The boiler is a single furnace, single reheating, four-corner opposed tangential firing (or opposed wall firing), balance draft, pulverized coal combustion, outdoor arrangement, dry bottom, steel structure, "π" shape Supercritical sliding operating Benson Type boiler. The efficiency of the boiler is stated as 93.5%.

b) Steam Turbine

The steam turbine is a supercritical parameter, single reheating, two cylinders and two exhausts, single-shaft, condensing type unit model N350/24.2/566/566 with a rated rotation of 3000 revolutions/min, clockwise rotating direction and permitted frequency variation of 48.5 to 50.5 Hz. The main steam inlet pressure is 24.2 MPa(a) and the inlet temperature is 566^{0}C and the output power is rated as 350MW.

c) Generator

The generator is a three-phase two-role synchronous generator with a self-shut static excitation system and Water-Hydrogen-Hydrogen cooling type. The rated power is 350MW with a power factor of 0.85, rated voltage of 20kV and rated rotation of 3000 revolutions/min having efficiency of ≥98.9%

d) Expected Performance

Table 3-3 Expected Performance of the Power Plant

Description	**Unit**	**Value**
Annual Utilization Hours	h/a	7000
Turbine Heat Rate	kJ/kWh	7730
Boiler Efficiency	%	93.5
Gross Efficiency of the power generation unit	%	43.11
Standard Coal Consumption for power generation (gross)	g/kW·h	285.3
Net Efficiency of the power generation unit	%	40.60

3.2.2 Thermo-mechanical Process System

The thermo-mechanical process system is schemed to fully consider elements such as power plant characteristics, power generating capacity and quantity and operating safety and reliability due to the long utilization hours and high availability demands of the power plant.

a) Main Steam, Reheat Steam, Turbine Bypass System

Main steam pipe and reheat steam pipe are designed as unit system with bypass systems in series to facilitate operation of the unit. The pipes are seamless pipes.

b) Steam Extraction System

The turbine units have eight stage unadjusted extractions, supplying steam to three high pressure (HP) heaters, four low pressure (LP) heaters and the de-aerator.

c) Auxiliary Steam System

The auxiliary steam system is a manifold system, each having an auxiliary steam header and connecting pipe between two headers. The auxiliary steam is generated from the auxiliary boiler and high pressure cylinder exhaust.

One oil-fired auxiliary boiler with capacity of 35t/h would be provided for the unit start up.

d) Feed Water System

Feed water system is designed as unit system having 2x50% steam-driven Boiler Feed Pumps and 1x50% motor-driven Boiler Feed Pumps with hydraulic coupling for each turbine-generator set. The feed water pump is provided redundant configuration to meet the high reliability requirement of the project.

Three high pressure feed water heater are set for each unit with one common bypass.

e) Condensate System

The condensate system includes condensate extraction pump (CEP), four low pressure heaters, one gland steam condenser (GSC) and one condensate polishing system. The CEP is 2x100% vertical centrifugal design, one unit operating with one on standby.

f) Heater Drains and Vents

Water drainage from the High Pressure heater is cascaded: No.1 HP heater drains to No.2 HP heater, No.2 HP heater drains to No.3 HP heater, and No.3 HP heater drains to deaerator.

The drainage of Low Pressure heater drains water is similar. No.5 LP heater drain to No.6 LP heater, No.6 LP heater drain to No.7 LP heater, No.7 LP heater drain to No.8 LP heater, and No.8 LP heater drain to condenser.

g) Air Evacuation and Vacuum System
Two 100% capacity mechanical rotary vacuum pumps would be provided, one working and the other on standby under normal operation condition. The two pumps work together to shorten the start-up time during start-up period.

h) Cooling Water System
For each unit, there would be two circulating water pipe introduced into the condenser to cool turbine exhaust steam and discharged into the circulating water returning piping outside the main power building.

The Auxiliary cooling water system is a large closed system, which include two closed water pumps, two closed water heat exchangers and one closed expansion tank.

3.2.3 Pulverized Coal Preparation and Combustion System

A medium speed mill, primary air fan positive pressure direct-firing pulverizing system is recommended for burning bituminous coal. Boiler combustion system would be four corners opposed tangential firing burners or opposed front and rear wall whirl firing burners.

a) Pulverized Coal Preparation System
The type of the mills and the pulverizing system are selected based on the quality of coal and the possible variation of the coal categories, load characteristics, applicable conditions of the mills as well as the structures of boiler furnaces and burners.

The main equipment of pulverized coal preparation System would include:

- Five (5) medium speed mills with four in service and one on standby;
- Five (5) gravimetric type coal feeders;
- Five (5) raw coal bunkers for each boiler.

b) Air and Flue Gas System
The combustion system adopts balancing ventilation mode. Primary air and secondary air are heated in air heater at the same time. The Primary Air Flow and Forced Draft Flow suction ducts are provided with silencers and an interconnecting duct connects the outlet ducts of two Flow.

Main equipment of Air and Flue Gas System include:

- Two (2x50%) Forced Draft Fans with variable moving blade axial fan
- Two (2x50%) Primary Air Fans of centrifugal type
- Two (2x50%) Induced Draft Fans
- Two (2x 100%) Sealing Air Fans of centrifugal type to be provided for the sealing of coal mills, one of which is as standby
- Two high-efficiency electric-static precipitators (ESP)
- Two boilers share one single-inner-flue-duct sleeve chimney, whose height is 180m and outlet diameter is 7.2m

c) Ignition and Combustion-supporting System
In order to reduce oil consumption, the plasma ignition technology is recommended for this project considering the coal specifications. And the original oil burner system will still be reserved as backup to guarantee the high reliability of the project.

Diesel oil is proposed for the fuel oil, which would be transported by road tankers. The fuel oil storage equipment would be arranged outdoor and would include:

- Two diesel oil tanks, the volume of each one is 300m^3
- Two diesel oil unloading pumps (one on standby)
- Two diesel oil supply pumps (one on standby)
- One dirty oil pump and one wastewater pump
- Related inlet strainers

3.2.4 Electrical System

The power generated by the 2×350MW supercritical power generation units would be evacuated at 330kV level. The main transformer of each unit would deliver power to the 330kV switchyard of the plant by means of overhead conductors. According to the planned capacity of the power plant, the evacuation voltage, one breaker and a half connection is recommended for the 330kV switchgear installation of the plant.

The project would be connected to the Power Grid with 300kV transmission lines. The connection to the Power Grid comprises of three 330kV outgoing lines are planned to connect to the grid: two outgoing lines (2X15km) to the break-in connected on the Aboadze-A4BSP 330kV transmission lines and an additional 90 km 330kV outgoing line connected to A4BSP (See ***Figure 3-4***).

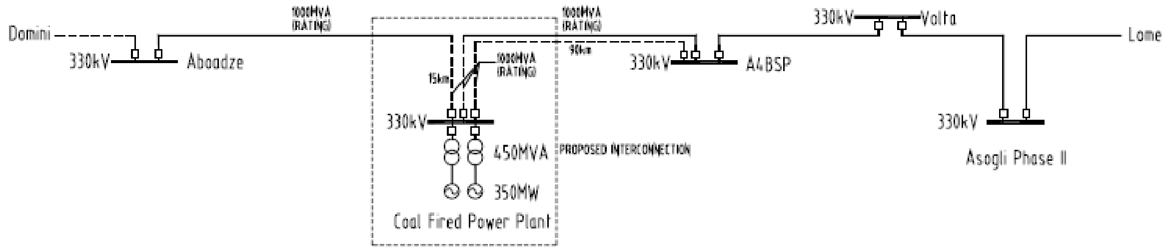


Figure 3-4 Interconnection Single Line Diagram

a) Main Electrical Equipment

The rated capacity of the generator is given as 350MW with the rated voltage of 20kV and a rated power factor of 0.85 (lag), which matches the steam turbine rated output. The continuous maximum capacity of the generator matches the turbine maximum continuous output capacity. The cooling system of the turbine generator unit would be “water-hydrogen-hydrogen” type with static excitation system.

The use of gaseous hydrogen as a coolant is based on its properties, namely low density, high specific heat, and the highest thermal conductivity (at 0.168 W/(m·K)) of all gases; it is 7-10 times better at cooling than air. For stator cooling, water can be used.

The main transformer is proposed to choose 450 MVA with off-load tap-changer, to 363 ±2×2.5%/ 20 kV.

The unit transformer is proposed as follows: mineral oil filled ONAF (Oil Natural Air Forced) split winding transformer with OLTC (On Load Tap Changer) and both have a capacity of 45/27-27MVA (provisional), voltage ratio 20±2×2.5%/ 6.3-6.3kV.

b) 330KV Electrical Equipment

The switchgear is recommended for indoor SF_6 Gas Insulted System (GIS).

The 330kV switchgear will be one and a half circuit breaker connection, its rated breaking current meeting 63kA, and dynamic stable current meeting 160kA.

c) Auxiliary Electrical System

The voltage of the auxiliary electrical system of the plant is dual classes as 6kV (middle voltage), and 380/220V (low voltage).

There will be two sections of medium voltage bus, with nominal voltage of 6kV, and this project will not set 6kV station section. The medium voltage motors and the as spare of low voltage transformers of the unit supplied by the two different unit sections, and the common loads will be shared to the two unit sections.

d) Emergency Power Supply System

One set of fast start Diesel Generator is set for each unit to meet the emergency power requirement.

e) DC (Direct Current) System and AC (Alternating Current) UPS (Uninterruptible Power System)

Each unit would have two battery sets for power and control unit load. The DC distribution panels are set according to load in main building and nearby auxiliary work shop. Two sets of 220V battery are set in the network relay room in the switchyard and two or three sets of 220V battery are set in auxiliary work shop. Also one set of 220V static UPS system with single-phase output would be set for each unit.

3.2.5 Coal Handling System

The coal handling system is considered accordingly for the 2x350MW coal-fired supercritical units to include ship unloading system, coal storage system, conveyor belt system, screening and crushing device.

The ship unloading system includes two sets of bridge type grab vessel unloader, and the rated capacity of each unloader is 1500 tons per hour. The coal is discharged from the ship onto the belt conveyor, which transports it to coal stockyard.

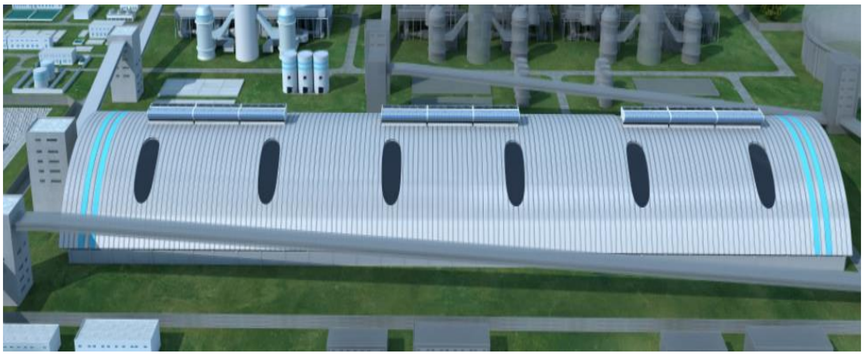


Figure 3-5 Enclosed Coal Stockyard

The coal storage system (See ***Figure 3-5***) includes one enclosed strip coal stockyard of length 400m and width of 114m provided on site, which can hold 18.1×10^4tonnes and capable of serving the two boilers for 30-day operation. The stockyard is fitted with two stacker-reclaimers installed on common rail with the stacking capacity of 3000t/h and the reclaiming capacity of 500t/h. The two stacker-reclaimers can also blend the coal in the coal stockyard. Bulldozers and loaders would be provided for auxiliary works in coal stockyard. Also, water spray system is provided in coal stockyard for dust suppression and safety monitoring device would be installed.

The belt conveyor system includes two parts: coal unloading system and coal delivery system. The coal unloading belt conveyor from the terminal to the stockyard has capacity of 3000t/h matching the ship unloading equipment. The coal delivery belt from the stockyard to the coal bunker has capacity of 500t/h. All the conveyors except in the stockyard are double routed to provide standby facility.

Double screening and crushing devices are provided for operational and standby functions. The screens capacities are 500 t/h each and crushers capacities are 400t/h each. The input size of screen and coal crusher is 300mm and output size will be 30mm.

Accessory devices and facilities of the coal handling system include belt scales, sampling devices, magnetic separators, and lifting cranes. Additionally, water cleaning system would be provided in all transfer points, crusher houses, coal silos, bunker bay and closed conveyor galleries for cleaning the coal handling system.

Dust Extraction System

Pulse fabric dust collectors would be provided at the main fugitive dust points such as coal transfer tower, coal crusher house and bunker bay on the basis that the coal handling equipment and skirtboard are strictly sealed. The dry-cyclone and pulse bag filters would be arranged for coal crusher house.

Vacuum Cleaning System

The boiler house would be provided with vacuum cleaning system, which concurrently functions to clean dust deposits in the bunker bay where the use water flush cleaning method not practical. The cleaning system would be provided for the ground floor, operating floor, boiler roof, access door of the boiler and belt floor. One movable vacuum cleaning car would also be provided to compliment the system.

3.2.6 Ash Handling System

Fly Ash Handling System

Dense phase pneumatic pressurized conveying system will be provided for the fly ash handling system. Fly ash collected in the Economizer and ESP (Electro-static Precipitator) hoppers is subsequently evacuated to the fly ash silo, where it is loaded onto vehicles and conveyed to the ash yard.

The system comprises of tank pumps equipped with pneumatic inlet valves, pneumatic outlet valves, manual gates, exhaust valves, air valves and other components. Fly ash collected in each hopper, passes through the manual gates, pneumatic inlet valve into the tank pumps. When the ash level reaches a predetermined position, or feeding time arrives the programmed setting value, the inlet valve will close, the outlet valve will open, and the air valve will open to convey the fly ash to silo through conveying pipes.

Each boiler would have a fly ash handling system, which operates separately. The unit would also have a capacity of 37t/hr, which satisfies 150% fly ash yield requirements at BMCR (Boiler Maximum Continuous rating) when design coal is burnt. Each unit has one 12m-diameter fly ash silo with a total volume of 1300m^3 and efficiency volume of 1020m^3, which can store fly ash from 24-hour operation when design coal is burnt at BMCR.

Bottom Ash Handling System

Air cooling steel belt conveyor mechanical type system will be provided for the bottom ash handling system, which comprise of mechanical conveying, storage and unloading system.

The high temperature bottom ash from the boiler furnace discharged through the ash hopper and dropping onto the steel conveyor is then cooled whiles conveyed to the bottom ash silo. The cooling air recovers the heat of the bottom ash to the boiler furnace. From the ash silo, the bottom ash would be unloaded to vehicles and transported to the ash yard.

Each boiler would have one unit of air cooled steel belt mechanical conveyor with maximum capacity of 10t/h. Each boiler would have one steel structure ash silo with a diameter of 6m and capacity of $100m^3$, capable of storing about 24-hour bottom ash discharged from the boiler when design coal is burnt at BMCR. Dry ash unloader and double paddle mixer would be provided for bottom ash unloading onto vehicle.

Pyrite Mill Handling System

A pyrite mill handling system would be provided for milling rejected stones. One set movable bucket and forklift system would be provided for storage and transfer of rejected stones to a vehicle outside the boiler house for the mill.

3.2.7 Chemical Water Treatment System

The chemical water treatment system includes seawater desalination system, boiler make-up water treatment system, condensate polishing plant, industrial waste water treatment system, chemical dosing system for the thermodynamic system, steam and water sampling system, cooling water treatment system, auxiliary boiler dosing and sampling system, hydrogen generation station, transformer oil treatment device and laboratory.

a) Seawater Desalination System
Seawater will be the main source of the power plant after desalination during the operational phase, including process water and portable water.

- Process water

The seawater desalination system for process water involves:

Raw seawater → coagulation and clarification →Clarified water tank →Double-layer filter → UF (Ultra-Filtration) equipment →UF water storage tank →seawater RO (Reverse Osmosis) →Sea water RO water storage tank

The capacity of seawater desalination system for process water is 2x140t/h, with one operating and the other as standby. Each RO unit has capacity to meet the requirements of normal make-up water quantity for the whole plant, therefore capable of providing the needed allowance for maintenance and chemical cleaning works.

- Portable water

The seawater desalination system for portable water would be an independent equipment which involves:

Raw seawater → coagulation and clarification→ membrane treatment → disinfection → mineralization

The capacity of seawater desalination system for portable water is 27 t/h. The quality of the water after treatment will meet the requirement of WHO guidelines for drinking water quality.

b) Boiler Makeup Water (DM (Demineralized) Water) Treatment System

Seawater is the source of the water for the boiler makeup water treatment system after desalination. The DM water treatment is as follows:

Fresh water from sea water desalination system →Primary RO (Reverse Osmosis) equipment →Primary RO water tank →Primary RO water pump →Secondary RO equipment →Secondary RO water tank →EDI (Electro-deionization) feed water pump →EDI equipment → Demineralized water tank →Demineralized water pump →To Boiler

The capacity of the DM water treatment system is 2×37m^3/h, with one operating and the other as standby

c) Condensate Polishing Plant

The condensate polishing plant is used to filter and purify condensate. It is frequently composed of pre-filters and mixed bed, which is filled with polymer resins to remove ions so that the purity of the condensate is maintained at or near that of DM water.

The condensate polishing system would be a medium-pressure system involving a condensate polishing plant for each unit, which includes 2x50%

pre-filters and 3x50% mixed bed. One set of external regeneration system would be furnished to regenerate the polymer resin for the two units.

d) Chemical Dosing System for Thermodynamic System

The chemical dosing system would be set to feed boiler condensate and feed water system to maintain the specified water quality.

The two units use a single set of dosing system, which comprises of ammonia dosing device for condensate and feed water, oxygen dosing device for condensate and feed water, hydrazine dosing device for feed water, and ammonia and hydrazine dosing device for closed circulating water.

e) Steam and Water Sampling System

One set of Steam and Water Analysis Sampling System device would be provided for each unit to monitor and control the steam and water quality.

f) Wastewater Treatment System

The wastewater system is separately arranged and all kinds of wastewater would be reused after processing respectively.

The industrial wastewater after treatment would be reused as the cleaning water for the reclaimer and stacker. The sewage would be collected to the sewage treatment station by pipelines, treated and then reused as sprinkling water for green belt. The coal wastewater would also be separately treated and reused for coal handing system washing.

- Industrial wastewater treatment system

  An industrial wastewater treatment system with a capacity of 100t/h is provided for treatment of regular wastewater and another 100t/h for the irregular wastewater. The total capacity of wastewater ponds is 4000m3.

  The process involves regular wastewater neutralization by acid or alkali for reuse or discharge. Irregular wastewater treatment process involves:

  Irregular effluent→ wastewater pit→ Flocculation tank→ Inclined plate settler → Final neutralization pit→ Clear-water basin→ discharge

- Domestic sewage treatment system

  The capacity of sewage treatment system is proposed as 2x10t/h.

- Coal wastewater treatment system

  The capacity of coal wastewater treatment system is proposed as 2x20t/h.

- Oily wastewater treatment system

  The capacity of coal wastewater treatment system is proposed as 1x 5t/h.

g) Auxiliary Boiler Dosing and Sampling System

The auxiliary boiler is also equipped with ammonia dosing device and sampling equipment.

h) Hydrogen Generation Station

A hydrogen generation station would be installed to provide the cooling gas for the Generator.

The use of gaseous hydrogen as a coolant is based on its properties, namely low density, high specific heat, and the highest thermal conductivity (at 0.168 W/(m·K)) of all gases; it is 7-10 times better at cooling than air. Another advantage of hydrogen is its easy detection by hydrogen sensors.

The system comprises of two medium pressure hydrogen generation plants based on electrolyzing water, and its capacity is 2x5 m^3/h, with one operating and the other as standby. Four hydrogen storage tanks with a volume of $13.9m^3$ for each would be equipped to storage the hydrogen at a pressure of 3.2MPa.

i) Transformer Oil Treatment Device

A mobile vacuum filter would be provided for purification of transformer oil.

j) Chemistry Lab

The laboratory table and appropriate instrument would be provided accordingly to the requirements of the 350MW units.

3.2.8 Cooling Water System

Once-through circulating seawater system is proposed and would be arranged with two circulating water pump provided for each unit.

The water intake facilities would be laid within the dock basin, at the south side of breakwater with a water depth of -5.0 m. And the circulating water pump house would be situated besides the coal stockyard.

The discharging method is proposed as rectangular precast concrete channel with the size of 2.4m×2.4m, and the discharging point would be arranged on the left side of the breakwater with a water depth of -3.0 m.

The Cooling Water system flow process is represented as:

Intake water point →water inlet channel →pump house forebay → steel gate →cleaning machine→ rotating type screen→ CW pump→ hydraulic butterfly valve → water inlet pipe→ condenser → water outlet pipe →siphon well→ outlet water channel → sea

The Turbine Maximum Continuous Rating (TMCR) condition of 350MW condenser flow is about 672.2 t/h and the cooling rate is 60 times all the year round. Accordingly, the flow rate of circulating water is presented in ***Table 3-4***.

Table 3-4 Flow Rate of Circulating Water

Unit capacity （MW)	Condenser flow（t/h）	CW flow rate for Condenser （m^3/h）	CW flow rate for auxiliary equipment （m^3/h）	Total CW flow rate （m^3/h）
1×350	672.2	40350	2800	43150
2×350	1344.4	80700	5600	86300

<u>Cooling Water Treatment System</u>

Periodic chlorination of the CW system will be required to maintain efficient operational capacity. Without treatment to remove biofouling, colonisation by barnacles, bivalves and other marine flora and fauna can rapidly become a problem and clog up conduits and condenser tubes. The control of biofouling will be achieved by use of chlorinated seawater as a biocide, produced by means of electro-chlorination.

Two sets of electrolyzed seawater chlorination device would be included for cooling seawater treatment, with one operating and the other as standby.

3.2.9 Ash storage Yard

The ash storage yard would be arranged at a valley with a primary rock-filled dam set at downstream and a flood control rock-filled dam set at upstream. The dams are designed to hold 30-year return period flood volume and over height of 0.5m and 100-year return flood volume over height of 0.3m.

The detailed layout of the ash storage yard is attached in ***Appendix 1: General Layout of the Project***.

The top level of the primary dam is 22m and width of dam crest is 4m and the top level of the flood control dam is 30m with a width of dam crest of 3m. The slope for both sides is 1:2 and the protection of both sides adopts 300mm thick dry block stone. In order to prevent seepage, composite geomembrane would be set under the inside protection layer, and rubble cushion also set at both sides of composite geomembrane to protect it.

When the ash level is 25.5m, it can form a volume of 170×10^4 m^3, which provides space for five-year ash storage.

Flood Influence at Ash Storage Yard Site

According to hydrological data, north side, east side and west side are affected by flood. Two drainage systems are set in the ash storage yard comprising a drainage system of 'flood control dam, drainage trench and stilling pool' which would lead flood from north to stilling pool at downstream; and another drainage system of 'drainage well, drainage trench and stilling pool' which would lead flood from east and west to the stilling pool at downstream. It also leads rainwater in the ash storage yard to the stilling pool. Flood above in the stilling pool would be led to natural gully and into the sea finally.

Access road

During construction and operation, a new access road would be constructed out of the eastern side of the green belt to join part of the existing road lying south of the ash yard. The road would connect the natural road on the south and north of ash storage yard and would also be for public use.

3.2.10 Flue Gas Emission

During normal operations, stack emissions will contain nitrogen oxides, sulphur dioxide, and particulates. Traditionally coal-fired power plants have been highly polluting. The continued use of coal as the fuel of choice for power generating plants have been due to the clean coal technology, the new generation of energy processes that sharply reduce air emissions and other pollutants compared to older coal-burning systems.

The measures to reduce the fuel gas emission of the project includes Low NOx Burners, Selective Catalytic Reduction (SCR) process, Electrostatic precipitators (ESP) and Seawater Flue Gas Desulfurization (FGD) process. The order of these systems is shown in ***Figure 3-6***.

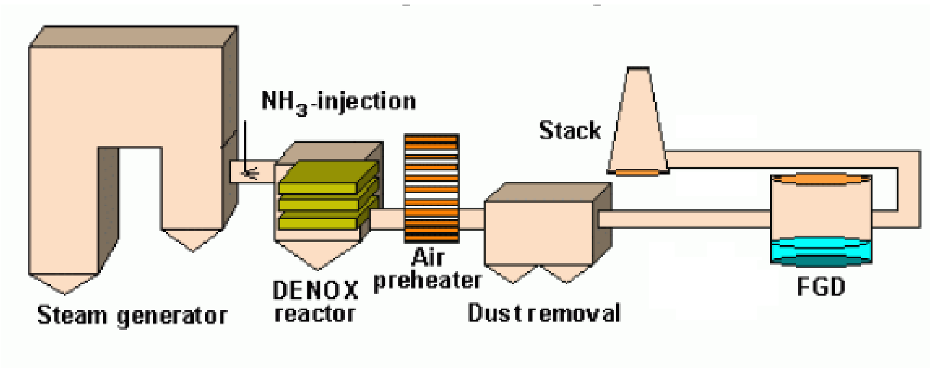


Figure 3-6 Arrangement of Flue Gas Emission Mitigation Systems

<u>Nitrogen Oxides Emission Control</u>

The combustion of coal in the presence of nitrogen, from either the fuel or air, leads to the formation of nitrogen oxides. Technologies to reduce NOx emissions are referred to as either primary abatement and control methods or as flue gas treatment. Primary measures include the use of low NOx burners and burner optimisation techniques to minimise the formation of NOx during combustion. Alternatively, technologies such as Selective Catalytic Reduction (SCR) and Selective Non-Catalytic Reduction (SNCR) lower NOx emissions by treating the NOx post-combustion in the flue gas.

a) Low NOx Burners

In a classical combustion installation, the combined fuel and air/oxygen mix is entirely injected at the same place. The resulting flame is then composed of a hot and oxidising primary zone located at the flame root and a colder secondary zone located at the flame end. The primary zone generates most of the NO, which increases exponentially with temperature, whereas the contribution of the secondary zone is rather modest.

Low NOx burners modify the means of introducing air and fuel to delay the mixing, reduce the availability of oxygen, and reduce the peak flame temperature. The burners retard the conversion of fuel-bound nitrogen to NOx and the formation of thermal NOx, while maintaining high combustion efficiency. The pressure drop in air ducts increases, causing more operational expenses.

With the adoption of low NOx burners, the concentration of NOx in the flue gas will be less than 350mg/Nm^3 at the entrance of SCR.

b) Selective Catalytic Reduction (SCR)

SCR is served as a secondary end-of-pipe technique to reduce the nitrogen oxides (NO_X) already formed. It can be implemented independently or in combination with primary measures such as a low NO_X burner, etc.

The SCR process is a catalytic process based on the selective reduction of nitrogen oxides with ammonia or urea in the presence of a catalyst. The reducing agent is injected into the flue-gas upstream of the catalyst. NOx conversion takes place on the surface of the catalyst at a temperature usually between 170 and 510 °C, by one of the following main reactions.

$$4\ NO + 4\ NH_3 + O2 \dashrightarrow 4\ N_2 + 6\ H_2O$$
$$6\ NO_2 + 8\ NH_3 \dashrightarrow 7\ N_2 + 12\ H_2O$$

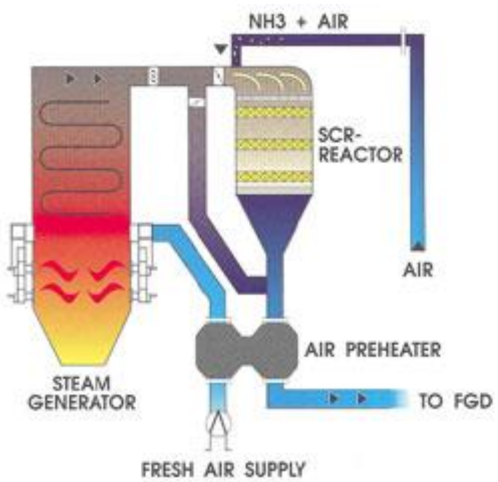


Figure 3-7 Basic Principle of SCR Process

The basic principle of SCR process is shown in ***Figure 3-7***.The reaction occurs in the pores of the catalyst bank. The catalyst bank may consist of one or more layers of catalyst for treatment. On the surface of the catalyst, the NOx will be selectively reduced by reacting with ammonia in the presence of oxygen to form harmless byproducts, water and nitrogen (H_2O & N_2).

Considering the safety of transportation and storage, Urea is selected as the reductant of the SCR process for the project. A Pyrolysis System is installed to convert urea to ammonia through thermal decomposition in order to be used as an effective reductant.

With the implementation of the SCR system, the concentration of NOx in the flue gas will be less than 200mg/Nm^3, which would meet the requirement of EPA Guideline.

c) Availability of SCR

The reliability and stability of the SCR System is vitally important for the control of the NOx emission. Generally, the availability rate of SCR System is defined as:

$$Availability Rate = \frac{A - B - C}{A} \times 100\%$$

in which,

A- hours when the system is applicable to operate,
B- hours when the system is forced to shut down,
C- hours when the NOx emission is more than the standard value.

For the 2x350MW Supercritical Power Plant, the availability rate of SCR will be required to be more than 98%.

Particle Matter Emission Control

Particulate emissions are finely divided solid and liquid (other than water) substances that are emitted from power stations. A number of technologies have been developed to control particulate emissions and are widely deployed.

Electrostatic precipitators (ESP) are the most widely used particulate control technology and use an electrical field to create a charge on particles in the flue gas in order to attract them to collecting plates.

An electrostatic precipitator (ESP) consists of a hopper-bottomed box containing rows of plates forming passages through which the flue-gas flows. Centrally located in each passage are emitting electrodes energized with high voltage direct current, which is provided by a transformer/rectifier (T/R) set.

The electrical field is applied across the electrodes by a small direct current at high voltage (100 kV). The voltage applied is high enough to ionize the gas molecules close to the electrodes, resulting in a visible corona. The flow of gas ions from the emitting electrodes across the gas passages to the grounded collecting plates constitutes what is called corona current.

When passing through the flue-gas, the charged ions collide with, and attach themselves to, fly ash particles suspended in the gas. The electric field forces the charged particles out of the gas stream toward the grounded plates, where they collect in a layer. The plates are periodically cleaned by a rapping system to release the layer into the ash hoppers as an agglomerated mass.

The ESP is located after the air heater. Particles are removed from the gas stream in four stages:

- through application of an electrical charge to the dust
- through placement of the charged dust in an electrical field
- by capture (agglomeration) of the dust onto the collecting electrode
- by removal of the dust from the surface of the electrode.

ESP is highly efficient, removing over 99.55% of particulate emissions.

Sulphur Oxide Emission Control

a) Low Sulphur Fuel

In the European guideline <Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for Large Combustion Plants>, when discussing “Primary measures to reduce sulphur oxide emissions” in chapter 3.3.3, the first technique mentioned is the adoption of “a low sulphur fuel or fuel with basic ash compounds for internal desulphurization”. “Switching to low sulphur fuel is a measure which can significantly reduce SO2 emissions.” It is also stated in the IFC <Environmental, Health, and Safety Guidelines for Thermal Power Plants> that “When burning coal, giving preference to high-heat-content, low-ash, and low-sulphur coal.”

Therefore, the requirement for coal with high Net Calorific Value and low sulphur content has been included in the selection of coal source and initial design of the project. Moreover, strict limits for the total sulphur content of coal has been stipulated in all the three Coal Supply MoUs for the project, which is listed in ***Table 3-5***.

Table 3-5 Requirement for Sulphur Content in Coal Supply MoUs

Coal Source / Item	South Africa 1	South Africa 2	Columbia
Total Sulphur (adb)	≤ 1.0%	0.5-1.0%	0.75% typical
Net Calorific Value (arb)	5000-6000 kcal/kg	4800-6000 kcal/kg	5600 kcal/kg typical

b) FGD (Flue Gas Desulfurization) Technology

Flue gas desulfurization (FGD) is used to remove sulphur dioxide from flue gas which results from the combustion of coal fuel. According to the different desulfurater, FGD process can be divided into Limestone-Gypsum FGD process, Seawater FGD process and ammonia FGD process. As the project is situated along the coast line, the sulfur in the fuel coal is less than 1.0%, the cooling water system would be once-through cooling seawater system and the cooling water will seawater, Seawater FGD is adopted and would be arranged for the desulfurization process.

Seawater FGD utilizes seawater's inherent properties to absorb and neutralize sulphur dioxide in flue-gases. If a large amount of seawater is available near a power plant, it is most likely to be used as a cooling medium in the condensers. Downstream of the condensers the seawater can be re-used for FGD.

The flue-gas from the power plant leaves the dust collector, normally an electrostatic precipitator. The flue-gas is then fed to the SO_2 absorber, where it comes into contact with controlled proportion of the seawater, taken from the cooling water outflow of the steam turbine condenser. Due to the presence of bicarbonate and carbonates in the seawater, the sulphur dioxide of the flue-gas is absorbed. The acidified absorber effluent is mixed with additional seawater to ensure that the pH is at optimal level for the oxidation process. The introduced air forces the oxidation of the absorbed sulphur dioxide from bisulphite to bisulphate and removes dissolved CO_2. The water would be nearly saturated with oxygen and the pH value would be restored to neutral before the seawater is discharged back to the sea. The basic principle of the process is shown in ***Figure 3-8***.

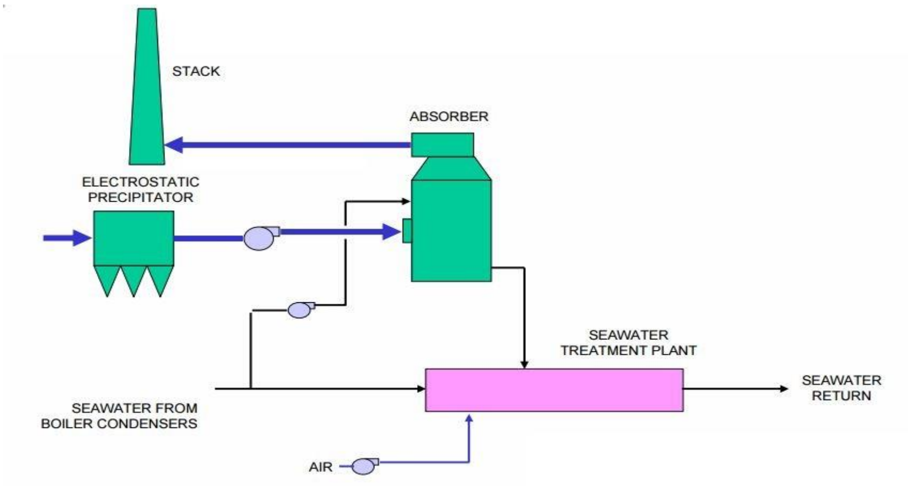


Figure 3-8 Basic Principle of Seawater FGD Process

The process is based on the following chemical reaction:

$$SO_2 + 2HCO_3^- + ½O_2 \text{-->} SO_4^{2-} + 2CO_2 + H_2O$$

After absorbing the SO_2, the acidified seawater collects in the absorber sump and flows by gravity to the seawater treatment plant (SWTP). The acidified absorber effluent is mixed with the rest of the cooling water in a special mixing unit in the front section of the SWTP and subsequently oxidized. Ambient air is blown into the seawater using heavy-duty industrial fans. The SO_2 will then be converted to sulphate (SO_4^{2-}), the absorbed SO_2 is oxidized to harmless sulphate ion, a natural constituent of seawater. The seawater will be nearly saturated with oxygen and the pH 6 level will be adjusted.

c) SOx Removal Efficiency of the Project

The emission of SO_2 will meet the Standard of Environmental, Health, and Safety Guidelines for Thermal Power Plants (International Finance Corporation World Bank Group December 19,2008), which stipulates that the emission limit of SO_2 is 200—850mg/m^3 for Boiler used solid fuels (Plant ≥600MWth) in Non-degraded airshed districts.

The chemical analysis of the coal samples shows that the total sulphur content of coal is 0.66%, 0.59% and 0.66% respectively. According to the total sulphur content and coal consumption, the SO_2 Concentration at the FGD plant inlet is estimated to be 1299.4mg/m^3, 1346.7mg/m^3, 1347mg/m^3 theoretically; in order to achieve the requirement of 200mg/m^3

of SO_2 emission, removal efficiency of 86% should be expected during normal operation. The detailed calculation is shown in ***Table 3-6***.

Table 3-6 Operation Efficiency of Seawater FGD

No.	**Item**	**Unit**	**South Africa 1**	**South Africa 2**	**Columbia**
1	Coal Consumption	t/h	131.7	140.3	129.3
2	Total Sulphur Content of coal, $S_{t,\ ar}$	%	0.66	0.61	0.68
3	Flue Gas Volume Flow at FGD plant inlet (wet, a=1.4)	m^3/h	1224537	1244516	1267354
4	Flue Gas Volume Flow at FGD plant inlet (dry, a=1.4)	m^3/h	1127540	1141859	1147182
5	Flue Gas Temperature at FGD plant inlet	℃	133.8	133.8	133.8
6	O_2 Content of the Flue Gas	%	6.09	6.09	6.12
7	SO_2 concentration at FGD plant inlet (S.T.P, dry, 6%O_2)	mg/m^3	1385.0	1344.7	1380.4
8	SO_2 removal efficiency	%	86%		
9	SO_2 concentration at FGD plant outlet (S.T.P, dry, 6% O_2)	mg/m^3	193.9	188.5	193.3

d) Availability of FGD

The reliability and stability of the Seawater FGD System is crucial for the control of the SOx emission. Generally, the availability rate of FGD System is defined as:

$$Availability Rate = \frac{A - B - C}{A} \times 100\%$$

in which,

A- hours when the system is applicable to operate,
B- hours when the system is forced to shut down,
C- hours when the SOx emission is more than the standard value.

For the 2x350MW Supercritical Power Plant, the availability rate of FGD will be required to be more than 98%.

3.2.11 Firefighting system

The design principle of the firefighting system would be based on "prevention first, extinguish combined with prevention" policy. The structure and arrangement of buildings would be set to ensure effective preventive measures for the incidence and spread of fire.

The important buildings and equipment would be furnished with two or more means for fire extinguishers. The generator transformer, auxiliary transformers would be furnished with water sprinklers and hydrant system.

Foam extinguishing system would be provided for the oil tank area and important oil filled equipment would be provided water spray extinguishing system. Fire extinguishing system for the control of the electronic equipment inside the control building and engineer room would adopt fire hydrant and configured portable fire extinguishers. Dumper chamber, coal yard, underground coal scuttle, transfer station, the overhead coal conveying belt would be provided water fire curtain and coal conveying trestle and coal layer would adopt automatic water spray. Raw coal bucket would be provided carbon dioxide inert gas fire extinguisher. One set of fire detection, alarm and control system would be provided for the power plant.

The power plant firefighting water network would be an independent system and purposely for the firefighting system. Firefighting water pump would be installed in the comprehensive water pump house, but with industrial and potable water pump using fireproof partition. Fire water supply system flow involves:

Service water and firefighting water basin →firefighting water pump →firefighting water pipe network. Fire water consumption is estimated as 653 m^3.

One water tanker truck and one dry foam combination truck would be provided for the power plant. A fire engine house and corresponding supporting equipment would be provided in the power plant. The project considers separately set fire water pump house equipped with two fire pumps installed in the pump house, one electric motor drive and one diesel engine driven fire pump, which would be standby fire pump, to ensure normal operation of the fire control system in case of accidental loss of electricity in the plant.

In the fire pump room, control room, operation layer and the main building and other major channels are set to start the fire pump button, which are also provided protective measures.

3.2.12 Automation and Control Systems

Centralized control mode would be adopted for boiler, turbine, generator network and BOP control system. There is one Central Control Room (CCR) for the two units and the centralized operation is considered to include all actions that will normally be undertaken to accomplish startup/ shutdown of unit, supervision of running state and handling abnormal condition and urgency accident etc. in CCR with the help of routine inspection and operations on site. The unit control system uses distributed control system (DCS).

Closed Circuit Television (CCTV) would be arranged for plant security and vigilance monitoring. Necessary equipment for supervision and control such as flame TV, large display screen, important parameters large digital displaying meters etc. would be mounted on assistant panel.

Water, coal and ash control system can be connected by auxiliary control network, and operator can supervise the process through LCD operator workstation. The centralized supervision of auxiliary control system will also be realized in CCR. The Desulfurization system would be controlled by unit DCS.

Automation systems of power plant are composed of Production Information System，DCS and the control system of auxiliary systems based on design principle of decentralization of control function and centralized information management.

Turbine diagnostic management system, tube leak detection system, fly ash carbon detection system would be arranged and in case of serious accident of DCS such as loss of power, communication interrupt, operator station defect, important controller fault etc. the unit can be shut down safely under the rule of “fail-safety” through the several hardwired emergency pushbuttons that mounted on the operator console in order to protect persons and equipment.

Five sets of Continuous Emission Monitoring System (CEMS) would be installed in stack and gas duct of desulfurization system. Fire Detection and Fire Fighting Control System arranged to realize automatic fire detection and alarm in the main building, desulfurization system coal handling and wherever prone to fire in Auxiliary system buildings. The control system would interlock with extinguishing equipment.

Heating, Ventilation and Air-conditioning (HVAC) control system would be arranged to integrate the vent of main building and air-conditioner systems in CCR and EER and engineer room would interface with the fire alarm and detection control system. Through auxiliary control network, the air conditioning systems and EER would be centrally controlled in CCR.

3.3 Pre-constructional Phase

The pre-constructional activities of the project involved pre-feasibility study, and feasibility investigations for the development and operation of 2X350MW Supercritical Coal-fired Power plant and the affiliated Coal Handing Terminal. A number of engineering investigations and analytical studies have been carried out to contribute to the project design and developing the basis for the feasibility evaluation of the project. These studies included Hydrological studies, Soil study, Marine Investigations, Geological Survey, Flood Risk Assessment, Dredging Assessment and Environmental and Social Impact Assessment and related independent reports.

The process also involved consultations with various identified stakeholders, both the affected and interested groups, on the development of the proposed 2X350MW Supercritical Coal-fired Power Plant and the affiliated Coal Handling Terminal and Material Off-loading Facility.

The consultation process involved presentation of the project features to various stakeholder interest groups to discuss issues of regulatory requirements and concern to the stakeholders. The details of the consultations are provided under ***Chapter 6 CONSULTATION*** of this report.

Furthermore, the phase involved project siting and land acquisition processes; including land survey and demarcation. Additional processes involved registration of the project in accordance with meeting the legal and regulatory compliance requirements for project development and securing permits for the project development activities. The relevant agencies include:

a) EPA, which would provide Environmental Permit following the submission of the Environmental and Social Impact Statement for the Project; presently the draft Environmental and Social Impact Statement is prepared.

b) Energy Commission, which would grant project Siting Permit and Provisional Generation Permit and Wholesale Electricity Supply License. Presently, the Project has just been introduced to the Commission.

c) Ekumfi District Assembly, which shall provide Building Permit and Business Operating License. Similarly, the project has been introduced to the District Assembly.

3.4 Constructional Phase

3.4.1 Earthwork

The longitudinal layout of the plant is planned in step-type direction with elevations between 3 metres and 24 metres of most natural grounds for the plant area with relatively large fluctuation of the terrain. The range and elevation of the plant area is set to provide optimal vertical layout of the plant area to guarantee the lowest quantities of earth-rock works and its related cost.

Table 3-7 Earthwork Quantity of the Project (Unit: 10^4 m^3)

No.	Item		Quantity	Remark
1	Plant Area (Construction product area included)	Filling	60.00	
		Excavation	180.00	Excluding the surplus earth of foundation trench, whose quantity is 20.00
2	Living area for builders	Filling	5.00	
		Excavation	5.00	
3	Affiliated Coal Handling Terminal	Filling	150.00	
		Excavation	5.00	
4	Ash Yard	Filling	11.60	Earthwork quantity of box dam grinding
		Excavation	4.70	Base clearance excavation and plant earth excavation
5	Road outside the plant	Filling	16.40	
		Excavation	32.50	
6	Living quarters for staff of power plant	Filling	3.00	
		Excavation	3.00	
	Total	**Filling**	**246.00**	
		Excavation	**225.20**	Excluding the surplus earth of foundation trench, whose quantity is 20.00

The earthwork quantity is presented in ***Table 3-7***.

Earthworks, explosion and construction engineering is accordingly planned in consideration of the process requirements, which set the plant area in four steps:

a) Plant front building, material warehouse and maintenance room, auxiliary facilities such as 330kV outdoor GIS are set for one step with 13 metres elevation of site levelling and 13.6 metres design elevation of indoor terrace level;

b) Steam turbine room, boiler house, precipitator behind the boiler, chimney, desulphurization facilities, ash bin, start-up boiler house, fuel oil facilities, aeration tank, waste water treatment facilities, hydrogen station etc. is set as another step with 8 metres elevation of site levelling and 8.6 metres design elevation of indoor terrace level;

c) Coal yard, coal handling terminal and water in-take pump house is set as one step with 6 metres elevation and 6.60m design elevation of indoor terrace level.

Retaining walls are set between the steps with roads connecting each other and satisfying transportation requirements. The volume of excavation for the plant area is calculated as 180×10^4 m^3 and the volume of filling is calculated as 60×10^4 m^3 with 20.00×10^4 m^3 surplus of earth. On the other hand, the volume of filling requirement of the coal handling terminal is calculated as 150×10^4 m^3. Consequently, the earth-rock in plant area would be balanced.

3.4.2 Water Consumption

The source of process water and portable water during the construction phase is proposed to be the Essakyir Water Treatment Plant (N 5°19'22.19'', W 0°52'33.65''), which is 12 kilometres away from the project. The quantity demand varies with different phases of the construction, and the peak demand is estimated to be $350m^3/h$.

According to Ghana Water Company Limited, currently the Water Treatment Plant operates at only 10% of its installed capacity of $14400m^3/d$ ($600m^3/h$). Therefore, the capacity of the Plant is able to meet the water demand for the construction phase.

3.4.3 Traffic Condition

The site can be accessed by the Accra – Cape Coast highway, branching off at the Ekumfi Essuehyia intersection southwards towards the sea through Otuam to the project site at Ekumfi Aboano. The road off Otuam is untarred feeder road.

Traffic condition of the project would largely be influenced by the supply of constructional materials. Heavy duty trucks including tipper trucks, articulated trucks, dampers and tankers would convey constructional materials, lubricants and fuel to the project site and also evacuate unwanted materials and waste from the site to designated disposal sites. Also, low loader and similar trucks would convey heavy duty constructional machinery to and from the site.

3.4.4 Construction Workforce

There would be a number of construction teams from China with immense technical expertise and abundant constructional skills, who could work on the power plant engineering construction. They would form the core construction team and a local construction team would also be established to compliment the operations. So the construction works would be undertaken by combined Chinese and local construction workers. It is expected that the construction process would generate employment for the youth within the Ekumfi District in particular and other areas in the country including the regional capital especially within the coastal areas in Ghana.

The constructional phase is envisaged to engage some 1000 Ghanaian workers in direct construction works including masons, carpenters, steel benders, electricians, welders and labourers while another 500 workers are expected to engage in indirect activities including drivers, security and cleaners. In addition, the project is expected to engage another 500 Chinese Nationals with constructional and related services skills.

On-site accommodation facilities would be provided for both foreign and local workers to reduce the impact of project related transportation.

3.4.5 Demobilization Strategy

On completion of construction works for the project, complete shutdown of the construction operation is anticipated. Preparation and shut down operation would include the following activities:

1. All equipment would be decontaminated and cleaned either at the primary support/utilization area or other designated area and demobilized/disassembled as needed when the project work ceases.
2. All equipment would be transported appropriately using appropriate facilities and guard.
3. Debris generated will be disposed of and the entire area cleaned to meet the relevant environmental standards and to the satisfaction of the District Assembly.
4. The storage areas both on-site and off-site would be appropriately secured and provided security to ensure limited access to unauthorised persons and the general public.
5. Remediation activities involving areas that were disturbed during construction activities will be restored to the degree practicable given the stage of the project. Any temporary fencing, temporary barriers and

sediment control measures in the work areas will be taken down as required.

6. A reduced office staff may continue working on site performing necessary post-construction and administrative activities for the commissioning phase of work and any remediation activities necessary to ensure minimal impact to any residents or stakeholders.

3.5 Operational & Maintenance Phase

The project assumes equipment utilization as 24-hour operation of rated output and annual operating hours as 7000hours.

The Environmental Flow of the Project is shown in ***Figure 3-9***.

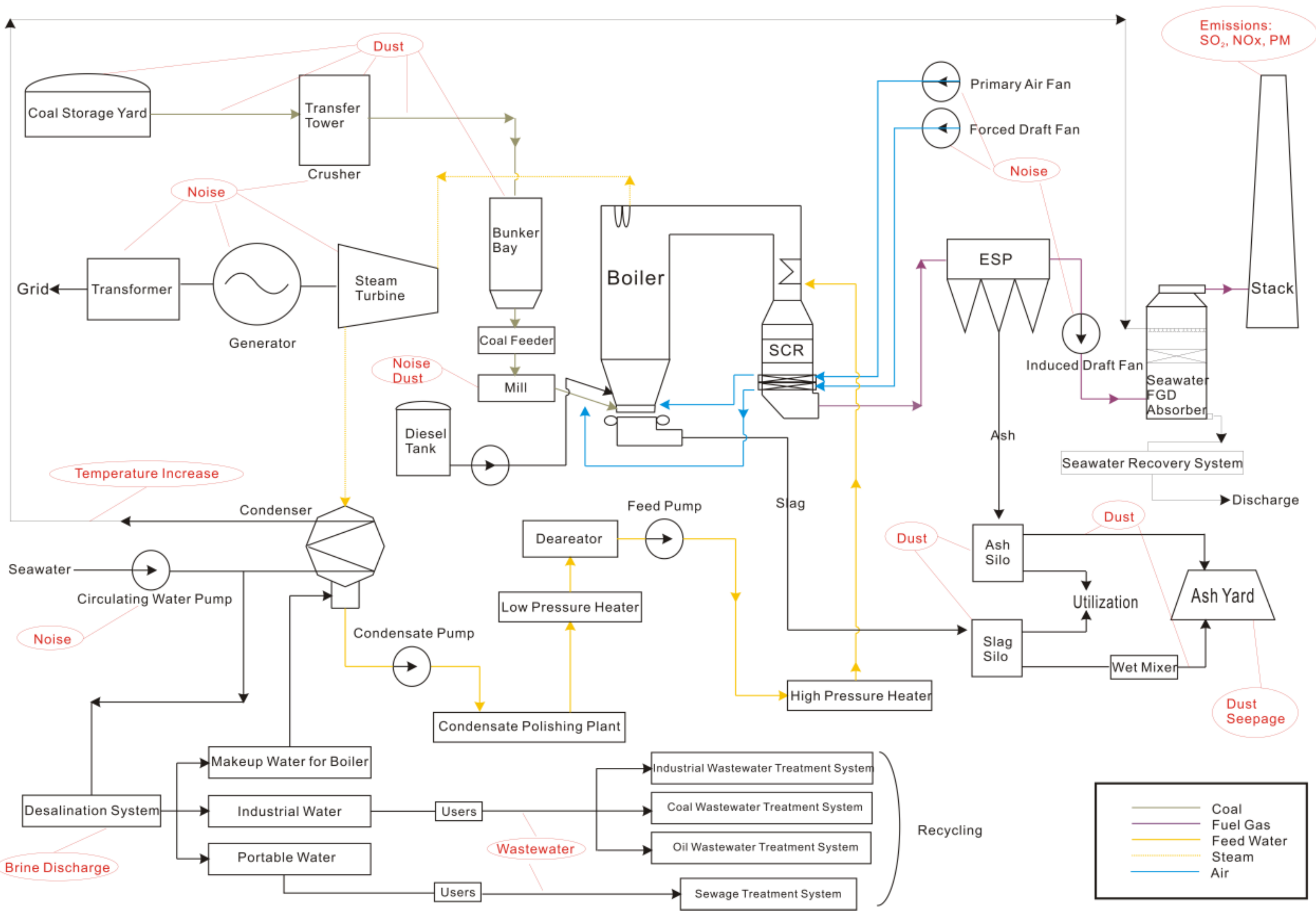


Figure 3-9 Environmental Flow of the Power Plant

3.5.1 Coal Supply

Coal Source

Coal consumption of the 2X350MW supercritical coal-fired power plant is estimated at about 2.0 million tonnes annually. Preliminarily, the principal source of coal for the project considers thermal coal imported from South Africa and shipped from Richards Bay in South Africa to the affiliated 70,000 DWT coal handling terminal of the power plants. Another coal source in Columbia is considered to serve as backup coal source for the project.

South Africa, where the coal would be obtained, has abundant coal resources and has demonstrated resources estimated at 30.156 billion tonnes accounting for 95.4% of demonstrated coal reserves in Africa. In 2013, the total coal production in South Africa was given as 256 million tonnes of which exports accounted for 72 million tonnes. Columbia is a global major coal producing and exporting company with its coal reserve estimated as 6.7billion tonnes in 2013. The country produced 88.6million tonnes of coal in 2014 and exported 70million tonnes.

A Wholly owned subsidiary of SEC, Sunon (Hong Kong) International Co. Ltd on behalf of SEC has established MOU with three coal producing and exporting companies. The agreement established a supply of 1.5million tonnes, 1 million tonnes and another 1million tonnes annually respectively. This arrangement meets the requirement of the annual coal consumption of 2 million tonnes. It is therefore concluded that the sources for coal to serve the 2X350MW supercritical coal-fired plant in Ghana in feasible and reliable.

Coal Specification

The South African thermal coal (with high Net Calorific Value and low sulphur content) would be the principal source of coal fuel for the power plant operation. The coal would be shipped at the South African Richards bay and then transport to the affiliated coal handling terminal of the power plant. The backup coal sources would be the coal sourced from Columbia.

According to the Coal Supply MOU with the three companies, attached in ***Appendix 3: Coal Supply MoU***, the type of coal earmarked for the project will be bituminous coal with the indicative specifications stipulated as in ***Table 3-8***.

Table 3-8 Indicative Coal Specification

Item \ Coal Source	South Africa 1	South Africa 2	Columbia
Total Moisture (arb)	12% max	7-15%	11.4% typical
Inherent Moisture (adb)	3.5% typical	3-8%	4.5% typical
Ash (adb)	15% max	12-25%	15.5% typical
Volatile Matter (adb)	22% min	20-30%	34.8% typical
Total Sulphur (adb)	1.0% max	0.5-1.0%	0.75% typical
Net Calorific Value (arb)	5000-6000 kcal/kg	4800-6000 kcal/kg	5600kcal/kg typical

The result of comprehensive analysis of coal samples delivered to the Thermal Power Research Institute in China revealed the following results presented in ***Table 3-9***.

Table 3-9 Detailed Coal Specification

Item	Abbreviation	Unit	South Africa 1	South Africa 2	Columbia
Proximate Analysis					
Total Moisture	M_t	%	3.1	6.8	10.9
Inherent Moisture (Moisture, air dried basis)	M_{ad}	%	2.76	2.51	5.90
Ash, as received basis	A_{ar}	%	17.44	16.39	15.70
Volatile Matter, dry ash-free basis	V_{daf}	%	32.43	29.63	41.90
Net Calorific Value (Low Heat Value)	NCV (LHV)	kJ/kg	25080	24170	23170
Net Calorific Value (High Heat Value)	NCV (HHV)	kJ/kg	25910	24970	24240
Free Silicon in Coal	SiO_2(F)	%	2.79	2.80	3.20
Free Calcium Oxide in Ash	CaO(F)	%	0.24	0.12	0.08
Ultimate Analysis					
Carbon, as received basis	C_{ar}	%	66.51	64.12	60.26
Hydrogen, as received basis	H_{ar}	%	3.68	3.13	3.98
Nitrogen, as received basis	N_{ar}	%	1.59	1.51	1.25
Oxygen, as received basis	O_{ar}	%	7.02	7.46	7.25

Total Sulphur, as received basis	$S_{t,ar}$	%	0.66	0.59	0.66
Chlorine, as received basis	Cl_{ar}	%	0.012	0.012	0.014
Phosphorus, as received basis	P_{ar}	%	0.017	0.019	0.023
Arsenic, as received basis	As_{ar}	μg/g	6	6	6
Fluorine, as received basis	F_{ar}	μg/g	106	101	116
Mercury, as received basis	Hg_{ar}	μg/g	0.157	0.145	0.165
Abrasion Index					
Hardgrove Grindability Index	HGI	/	46	57	53
Impingement Abrasion Index	Ke	/	0.6	1.2	1.3
Mineral Analysis of Ash					
Silica	SiO_2	%	46.41	55.97	64.01
Aluminium	Al_2O_3	%	28.69	26.31	18.82
Iron	Fe_2O_3	%	6.32	7.23	10.58
Calcium	CaO	%	9.82	4.25	0.85
Magnesium	MgO	%	2.57	1.43	1.38
Sodium	Na_2O	%	0.06	0.10	0.61
Potassium	K_2O	%	0.64	0.39	2.01
Titanium	TiO_2	%	0.89	1.66	0.06
Sulphur	SO_3	%	3.75	1.73	0.88
Manganese	MnO_2	%	0.026	0.031	0.045
Phosphorus	P_2O_5	%	0.458	0.536	0.660
Undetermined			0.366	0.363	0.095
Ash Fusibility					
Deformation Temperature	DT	℃	1340	1330	1320
Softening Temperature	ST	℃	1370	1340	1380
Hemispherical Temperature	HT	℃	1380	1350	1400
Flow Temperature	FT	℃	1390	1360	1450
Ash Resistivity (ρ_{CA}), Measuring Voltage: 500V					
Indoor Temperature	ρ_{CA}	Ω·cm	1.40×10^{11}	7.70×10^{11}	1.30×10^{9}
80℃		Ω·cm	2.80×10^{12}	3.20×10^{12}	1.80×10^{10}
100℃		Ω·cm	3.90×10^{12}	5.40×10^{12}	1.70×10^{11}
120℃		Ω·cm	7.70×10^{12}	8.20×10^{12}	5.90×10^{11}
150℃		Ω·cm	5.80×10^{11}	7.30×10^{11}	4.50×10^{11}
180℃		Ω·cm	8.20×10^{10}	6.90×10^{10}	6.00×10^{10}

Coal Consumption

The coal consumption of 2×350MW coal-fired supercritical generation units is calculated as shown in ***Table 3-10***.

Table 3-10 Coal Consumption of the Power Plant

Item	**Coal Consumption Hourly**		**Coal Consumption Daily**		**Coal Consumption Annual**	
	t/h		t/d		10^4 t/a	
	One Unit	Two Units	One Unit	Two Units	One Unit	Two Units
Design Coal	125.3	250.6	3007.2	6014.4	87.71	175.42
Check Coal 1	140.3	280.6	3367.2	6734.4	98.21	196.42
Check Coal 2	135.6	271.2	3254.4	6508.8	94.92	189.84

Notes:

(1) Equipment daily utilization hours are calculated 24h;
(2) Equipment annual utilization hours are calculated 7,000h;
(3) Hourly coal consumption is calculated as per BMCR operation condition.

3.5.2 Water Consumption

The Water Balance of the 2x350MW Supercritical Power Plant is attached as ***Appendix 2: Water Balance***. The quantity of the make-up water is listed in ***Table 3-11*** (including the water consumption for the Affiliated Coal Handling Terminal).

Accordingly, the maximum water consumption is 175 m^3/h, and the million kilowatts water consumption index is 0.069 $m^3/s\cdot GW$.

Table 3-11 Make-up Water Consumption

No.	Item	Water Demand	Recycling Water	Makeup Water Demand	Remark
1	Evaporation loss	2	0	2	Public system of the plant
2	Wind draft loss	0.5	0	0.5	Public system of the plant
3	Blow-down loss	16.5	16.5	0	Public system of the plant
4	Make-up water for boiler	55	9	46	
5	Potable water	10	8	2	
6	HVAC water	1	0	0	Heating, Ventilation, and Air Conditioning
7	Cooling water for air compressor	130	130	0	
8	Water for Bucket wheel machine & Stocker	13	0	13	
9	Washing water for coal handling system	28	18	10	
10	Cooling water for FGD system	45	45	0	
11	Bottom ash wetting	2	0	2	
12	Fly ash wetting	14	0	14	
13	Water supply for terminal	52	0	52	
14	Washing water for main house	5	0	5	
15	Service water for oil area	5	4	1	
16	Water for coal wastewater treatment system	3	0	3	
17	Water for industrial wastewater treatment system	1	0	1	
18	Water for sewage treatment system	1	0	1	
19	Water for greening of the plant	3	0	3	
20	Unforeseen water	18.5	0	18.5	
21	Total	405.5	230.5	175	

3.5.3 Coal Ash

Per the coal analysis data and the coal consumption rate, the quantity of ash produced by each boiler is calculated in ***Table 3-12***.

Table 3-12 Ash Quantity Calculation

Ash quantity per hour (t/h) per Unit				
	Bottom ash	Fly ash	Total	Pyrites
Design coal	2.26	20.34	22.60	0.63
Check coal 1	2.82	25.35	28.16	0.70
Check coal 2	0.87	7.87	8.74	0.68
Ash quantity per year (10^4 t/a) of the Project				
	Bottom ash	Fly ash	Total	Pyrites
Design coal	3.16	28.47	31.63	0.88
Check coal 1	3.94	35.49	39.43	0.98
Check coal 2	1.22	11.02	12.24	0.95

Note: The calculation is based on bottom ash covers 10% of total Ash, while fly ash covers 90% of total ash.

<u>Specification of Fly Ash</u>

The typical composition of fly ash has been listed in ***Table 3-13***.

Table 3-13 Specification of Fly Ash

Analysis Of Ash		**%Wt**
Silica	SiO_2	46.41
Aluminum	Al_2O_3	28.69
Sodium	Na_2O	0.06
Potassium	K_2O	0.64
Magnesium	MgO	2.57
Calcium	CaO	9.82
Iron	Fe_2O_3	6.32
Titanium	TiO_2	0.89
Sulfur	SO_3	3.75
Phosphorus	P_2O_5	0.458
Manganese	MnO_2	0.026
Undetermined		0.366

Environmental Protection Measures

The environmental protection measures include the following:

a) Anti-seepage Measure
Composite geo-membrane is set on the surface of bottom and inside slope for the ash storage yard. The effect of composite geo-membrane should be equal to performance of 1.0×10-7cm/s permeability coefficient or 1.5m thick clay soil.

b) Buffer Area
In order to decrease pollution of fly ash, 10m wide green belt would be set around ash storage yard. The green belt can improve landscape view of the surroundings and avoid influence of fly ash. The green belt would be composed of local trees and grasses.

c) Spraying water
Ash received at the ash storage yard would be rolled in time involving watering on the surface of the ash body. The rainwater drained into the stilling pool can be used as spraying water or water may be transported by truck to the Ash storage yard.

d) Monitoring
The ash storage facility would be monitoring twice a year in relation to the displacement and settlement set on top of the primary dam.

Utilization of the Coal Ash

Fly ash, bottom ash and pyrite can be used as material inputs in the production of concrete, cement and bricks as well as in construction work for road and pavement construction. During the construction phase of the BUI Hydroelectric Dam, huge volume of coal ash was imported into Ghana from China.

The project has established MoU with one Chinese company and one Ghanaian company to procure the coal ash and slag for construction purposes and production of coal ash blocks. The Coal Ash MoU is attached as ***Appendix 4: Coal Ash Utilization MoU***.

The two companies are Guangdong Guishan Building Materials Co., Ltd. and China State Hualong Construction (GH.) Ltd. (CSHLC). The first one is engaged in the utilization of fly ash and slag to sieve fly ash and produce coal ash blocks in China, while CSHLC is a comprehensive group corporation mainly engaged in industrial and civil buildings, construction of municipal roads and bridges, and international engineering contracting, and also deals with real estate development, decoration engineering, service works, building materials sales, concrete sales, construction machinery & equipment leasing, aggregates production and sales, import and export trade, and hotel management in Ghana.

A comprehensive coal ash utilization scheme has been planned for the project by the cooperation companies, which is also attached as ***Appendix 5: Utilization Scheme of Coal Ash***.

According to the MoU, each company shall endeavour to purchase up to 300,000 tons of fly ash and 30,000 tons of slag per calendar year when the 2x350MW Supercritical Power Plant becomes operational. The coal ash utilization facility would be situated near the proposed project site.

3.5.4 Flue Gas Emission

The main pollutants of the power plant are Particles, SO_2, and NOx. And the amount of emissions during normal operation is shown in ***Table 3-14***.

Table 3-14 Amount of Emissions During Normal Operation

Emissions		**Unit**	**Value**
SO_2	Concentration	mg/Nm^3	181.9
	Quantity	t/a	2898
Particulates	Concentration	mg/Nm^3	37.7
	Quantity	t/a	630
NO_X	Concentration	mg/Nm^3	200
	Quantity	t/a	3203
CO_2	Quantity	t/a	3.69×10^6

CEMS (Continuous Emission Monitoring System)

CEMS equipment will be installed on the inlet and outlet duct of the Seawater FGD, and also the stack. The concentration of SO_2, NOx, and Particulates in the flue gas will be monitored online and continuously during the operational phase.

3.6 Decommissioning

Decommissioning would involve dismantling of the physical structures and facilities developed in relation to the project. The physical structures of the power plant would include the boiler units, stacks, turbines, generators, desulfurization facilities, denitrification facilities, electrostatic precipitators, coal ash handling facilities, oil and chemical storage tanks, substation transformers and power transmission lines, civil structures and residential facilities, access roads and other related infrastructure and facilities.

A professional company would be contracted to undertake the dismantling operation, with the hierarchical priorities of alternative uses, reuse and recovering where possible before scrapping and demolition where necessary.

Where the local market for scrapped material is not found, the material would be shipped back to China. Detailed decommissioning operation for the power plant is provided under ***Chapter 11 DECOMMISSIONING.***

3.7 Work Schedule

An overall installed capacity of 2,000MW in total for the coal fired power plant project is planned to be developed, 2×350MW supercritical generating units are in phase I construction, and further extension conditions are reserved as planning.

The phase I project is planned to be commenced in December 2017 with all related preparation works accomplished. The two units will be completed and put into commercial operation in December 2020 and June 2021 respectively. The detailed timeline is shown in ***Table 3-15***.

Table 3-15 Construction Timeline of the Project

No	Date of Commencement	Date of Completion	Items
1	2015/1/1	2015/7/15	Pre-feasibiltiy Study (completed)
2	2015/8/1		Environmental & Social Research and Investigations
3	2015/9/1	2016/8/1	Feasibility Study (completed)
4	2017/12/31	2018/4/31	Five supplies and one levelling
5	2018/5/1	2018/7/1	Excavation of main powerhouse
6	2018/7/2		First concrete grouting of main powerhouse foundation

7	2018/7/2	2018/11/13	Foundation construction of main powerhouse
8	2018/7/2	2018/10/29	Foundation construction of chimneys
9	2018/10/29	2019/10/29	Internal and outer cylinders construction of chimneys
10	2018/12/1	2019/6/3	Hoisting of #1 boiler’s steel frame
11	2019/6/5	2020/2/29	Installation of #1 boiler’s heating surface
12	2020/3/1	2019/3/15	Hydrostatic test of #1 boiler
13	2019/3/16	2019/4/15	Acid cleaning and recovery of #1 boiler
14	2019/9/1	2019/9/30	Emplacement of #1 steam turbine sole plate
15	2019/10/1	2020/3/30	Installation of #1steam turbine proper
16	2020/4/3	2020/4/17	Cylinder cap installation of #1 steam turbine
17	2020/2/1		Qualified water produced from chemical water system
18	2020/5/15		Receiving of station-service power by #1 Unit
19	2020/10/1	2020/10/20	Ignition blowpipe and recovery of #1 boiler
20	**2020/10/21**	**2020/12/16**	**168 commissioning and transfer for trail production of #1 unit**
21	2019/5/1	2019/10/31	Hoisting of #2 boiler’s steel frame
22	2019/11/1	2020/8/15	Installation of #2 boiler’s heating surface
23	2020/8/16	2020/8/30	Hydrostatic test of #2 boiler
24	2020/9/1	2020/9/30	Acid cleaning and recovery of #2 boiler
25	2020/2/1	2020/2/30	Emplacement of #2 steam turbine sole plate
26	2020/3/1	2020/8/30	Installation of #2steam turbine proper
27	2020/9/1	2020/9/15	Cylinder cap installation of #2 steam turbine
28	2020/10/15		Receiving of station-service power by #2 Unit
29	2021/3/1	2021/3/25	Ignition blowpipe and recovery of #2 boiler
30	**2021/3/26**	**2021/6/8**	**168 commissioning and transfer for trail production of #2 Unit**

3.8 Estimated Costs

The 2x350 MW Supercritical Power Plant (including the affiliated coal handling terminal), which is planned to commence in December 2017 and commission commercial operation in 2020, is estimated to cost 1.5 billion US Dollars.

The cost for environmental protection measures of the power plant is estimated to be 127.20 million dollars, accounting for 8.47% of the total investment. The estimation is conservative since some budget for protection measure are not included such as Low NOx Burners, since generally the cost is categorized in the purchase cost for the boiler. The detailed engineering cost for environmental protection facilities is listed in ***Table 3-16***.

Table 3-16 Engineering Cost for the Environmental Protection Facilities

No.	Environmental Protection Measures	Cost (million dollars)	Remark
1	Flue Gas Duct and Stack	16.52	
2	Ash Handling System (including the Electrostatic Precipitator)	15.255	
3	Coal Handling System (including the enclosed measures for coal storage yard and dust prevention measures)	18.95	
4	Seawater Flue Gas Desulphurization System	33.38	
5	Low NOx Burners	NA	Generally the cost is categorized in the purchase cost for the boiler.
6	Selective Catalytic Reduction System	18.26	
7	Domestic Sewage Treatment System	0.27	
8	Industrial Wastewater Treatment System	4.03	
9	Coal Wastewater Treatment System	0.92	
10	Oily Wastewater Treatment System	0.26	
11	Noise Control Measures	NA	Generally the cost is categorized in the purchase cost for the equipment, and building cost of the plant and fence wall.
12	Mitigation Measures for Ash Storage Yard (including anti-seepage and dust prevention measures)	18.32	
13	Continuous Emission Monitoring System for the Flue Gas	0.5	
14	Reforestation for the Power Plant	0.53	
15	ESIA		
16	Monitoring Plan		Details are presented in Chapter 9
Total	**Environmental Protection Cost**	**127.20**	

4 PROJECT ALTERNATIVES

This chapter describes the alternative situation where the undertaking is not proceeded with and alternative designs options and site considerations evaluated in relation choice of technology engineering, environmental implications and optimum cost-benefit. A summary of these alternatives is listed in ***Table 4-1***.

Table 4-1 Summary of Alternative Technologies, Fuels, and Sites

CATEGORY	ITEM	OPTIONS		SELECTED OPTION
Technology Options	Power Generation	Natural Gas–fired Power Plant		Coal-fired Power Plant: Supercritical
		Coal-fired Power Plant	Ultra-supercritical	
			Supercritical	
			Sub-critical	
	Combustion Type	Pulverized Coal Combustion		Pulverized Coal Combustion
		Coal Gasification Option		
		Biomass Co-firing Option		
	NOx Emission Control	Selective Non-catalytic Reduction (SNCR)		SCR with Urea as Reductant
		Selective Catalytic Reduction (SCR)	Reductant: anhydrous ammonia	
			Reductant: aqueous ammonia	
			Reductant: urea	
	Flue Gas Desulfurization (FGD)	Limestone-Gypsum FGD		Seawater FGD
		Seawater FGD		
	Carbon Dioxide Emission Control	Carbon Capture and Storage		Carbon Sink
		Carbon Sink		
	Cooling System	Cooling Tower System		Once Through Cooling System
		Once Through Cooling System		
	Coal Storage Yard	Open		Totally Closed
		Partially Closed		
		Totally Closed		
Fuel Options	Coal Type	Bituminous Coal		
	Diesel Oil			
Site Options	Akwidaa			Ekumfi
	Ekumfi			

4.1 No Development Scenario

The situation of no development would depict a scenario in which the project area remains coastal savannah grassland and the land use pattern remained the same. Traditionally, the land use has been for subsistence farming practices; cropping mainly groundnuts, tiger nuts and cassava, this is likely remaining as such especially in the short term. Furthermore, it would be expected that the community would continue with the practices of hunting for rats and other rodents, which has also resulting in indiscriminate burning of grass vegetation and consequent bush fire. Again the project area would more likely continue to experience rampant cutting of trees for charcoal and firewood production.

Significantly, the land and vegetation are disturbed resulting from the economic activities and the poor management practices.

The instance of no development situation is therefore not likely to have any significant change in the social and economic set up of the area, and therefore the socio-economic situation of the people would not transform any significantly. However, the rapidly growing youth unemployment if not addressed could lead to significant social disaster.

Also, in a no development situation, the communities of Ekumfi would not experience the massive infrastructural development and economic transformation the project is likely to bring in.

4.2 Alternative Technologies

4.2.1 Alternative Power Generation

Traditionally, Ghana has developed two primary sources for commercial power generation identified as hydropower and thermal power. The thermal power has depended on principally on light crude oil and gas as the main fuel source. Generally, the country has remained dependent on limited sources of power generation, probably due to some important reasons.

In 2014, the total hydropower generation installed capacity is 1580MW and the total power generated was 8387 GWh, whiles the total installed capacity for thermal power generation is 1248 MW and the total power generation was 4572 GWh.

Until 1996, Ghana was solely dependent on hydropower generation sources; however, the risk of reduced water in the dams necessitated the development of thermal power as alternative source of commercial power generation. There have been two principal sources of fuel being light crude oil and natural gas. However, these two principal sources have faced high supply risk and attendant price volatility. Furthermore, the supply shortfall continues to increase as demand also continues to grow. Nonetheless, natural gas has remained the preferred fuel source for thermal power generation.

As alternative to the coal fired power generation, natural gas as fuel source is compared and discussed with the goal of assessing the long term operational efficiency and viability, engineering, economics and environmental impact and implications as basis for future developmental consideration.

Summary considerations of alternative fuel sources are provided as following:

Natural Gas–fired Power Plant

- Low emission of flue gas pollutants including CO_2
- High upfront investment requirement for transport and distribution system
- Increasingly long supply routes and high cost of infrastructure
- High price volatility and price hike of natural gas.
- High supply risk and long term availability
- Relative higher tariff
- High profitability

Coal-fired Power Generation

- High emission of flue gas pollutants including SOx, NOx, CO_2 and particulate in uncontrolled situation.
- Clean coal technology options considerably matured.
- Increased output (high annual utilization hours) and most suitable for baseload situations
- Not suitable for peaking generation units
- Higher efficiency above 40% using supercritical coal fired plant
- Require significant size of land
- Stable price and long term availability
- Low tariffs
- High profitability

These considerations conclude that a coal fired power plant would provide considerable overall power generation efficiency and reliability with optimum benefits to all stakeholders especially the consumers and shareholders therefore considered for a preferred option.

Flexibility Characteristics of Coal-Fired Power Plants

It is widely recognized that increasing flexibility is key for the reliable operation of future power systems with very high penetration levels of variable renewable energy sources and load losses. Power system flexibility represents the extent to which a power system can adapt electricity generation and consumption as needed to maintain system stability in a cost-effective manner.

Two key tasks for the power plant fleet were to follow all variations in the demand (variability) and to ensure that the system stays in balance in the case of the sudden loss of a generating unit (uncertainty). In this respect, ramp rates, minimum up/down times, and start-up/shut-down times are commonly used indicators of flexibility, measured as MW available for ramping up and down over time. The effects of highly variable output units from renewable plants onto a grid in the absence of sufficient large-scale electricity storage capability, forces coal and gas fired units to deliver greatly varying output to enable the power grid meet its load at all times.

Current strategies used in dealing with such problems is the degree of flexibility that allow coal-fired units to maintain faster ramp rates and operate at lower loads to minimise the need for on/off operation. These methods enable power plants to operate with least detriment to integrity, efficiency and emissions.

The rate at which power plants change load is called ramp rates. It is usually given in megawatts per minutes. During crises, a fast ramp rates is needed to prevent blackouts. A fast ramp rates is desirable because it keeps cost of generation down and save fuel whilst responding rapidly to load changes to re-match supply to demand within seconds so that the system frequency can be quickly restored. Higher thermal stresses on equipment components and subsequent fatigue reduce service life results with faster ramp rates. Key flexibility constraints come from the technical restrictions of each technology, defined by its ramping capability, must-run requirements and minimum load.

Coal Power Plants Are Highly Flexible -- A case study on the German electricity market demonstrates that coal fuelled units have considerable flexibility needed to follow dynamic grid operation caused when intermittent renewables are added to the electricity portfolio. This flexibility is critical to ensuring grid stability during extended use of intermittent wind and solar energy sources. (Source: IEA Coal Industry Advisory Board, 2013. 21st century coal: Advanced technology and global energy solution. Paris: OECD/IEA.)

In the regular configuration of two gas turbines and one steam turbine, the minimum load of a new gas-fired combined-cycle plant is typically around 60% of its installed capacity. An even lower minimum load is achievable by switching off one gas turbine; this, however, causes a substantial decrease in efficiency, and thus is rarely employed.

In contrast, a new coal-fired power plant has a lower minimum load capability of approximately 40%, with further potential to reduce this to 20–25%. The reason is that the output of the coal boiler is controlled via direct fuel combustion and not, as is the case with a gas combined-cycle power plant, via a heat recovery steam generator with an upstream gas turbine.

Moreover, in contrast to a subcritical boiler, supercritical boiler operates at pressures above the critical pressure, therefore the liquid water immediately becomes steam. This is ideal for sliding pressure operation which has much more flexibility in load changes and controlling the power grid.

For the 2x350MW coal-fired power plant, the minimum load can be lower to 35% of its installed capacity, with a maximum ramp rate of approximately 3 percentage points per minute. The detailed ramp rate under different load is listed in ***Table 4-2***.

Table 4-2 Ramp Rate of the 2x350MW Coal-fired Power Plant

Load	Ramp Rate
50%-100% TMCR (Turbine Maximum Continuous Rating)	5% /min
30%-50% TMCR	3% /min
Step Load Change	> 10% TRL /min (Turbine Rated Load)

4.2.2 Alternative Boiler Technology

Boiler Parameter

Considerations of energy independence and balance of payments, the greater price stability and lower cost of coal compared to natural gas, make coal a considered option for base load power generation.

The project feasibility study has reviewed coal-fired power plant technologies, particularly considering pulverized Subcritical Coal-fired Power Plant, Supercritical Coal-fired Power Plant and Ultra-supercritical Coal-fired Power Plant.

The Sub-critical pulverized coal-fired power plant, which makes water boil to generate steam that activates a turbine, has low efficiency of about 40%.

The Supercritical (SC) pulverized coal-fired power plant operates at temperatures and pressures above the critical point of water, i.e. above the temperature and pressure at which the liquid and gas phases of water coexist in equilibrium, and have higher efficiencies – above 43%.

The Ultra-Supercritical pulverized coal-fired power plants have higher efficiencies compared to supercritical and subcritical coal-fired power plants. The power plant efficiency is rated above 45%. However, ultra-supercritical technology is more appropriate for larger generation units.

Increasing the efficiency of a unit can lead to reduced emissions, lower coal consumption and less water usage[4]. Consequently, higher efficiencies result in less coal consumed per megawatt-hour. This therefore leads to lower emissions including carbon dioxide and mercury, higher plant efficiency and lower fuel costs per megawatt.

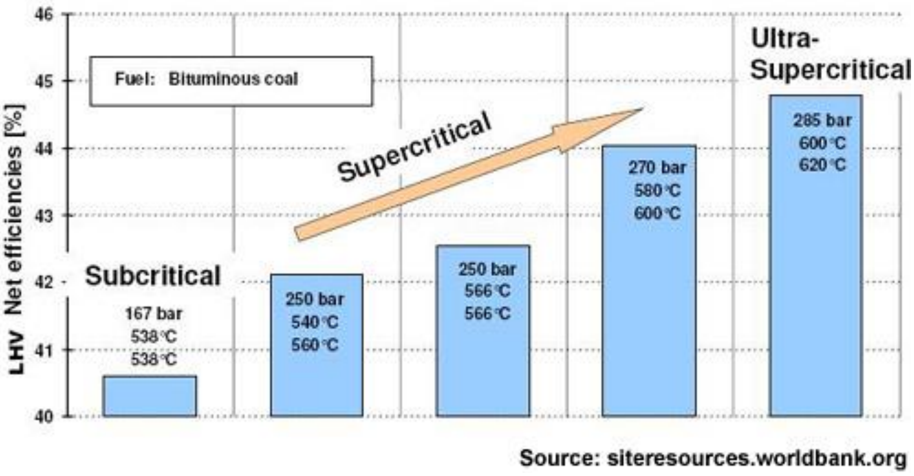


Figure 4-1 Efficiency of Coal Plants

[4] Emission Reduction through upgrade of Coal-Fired Power Plant; Learning from Chinese Experience, Partner Country Series, International Energy Agency OECD/IEA, 2014.

Table 4-3 Comparative Coal Consumptions and Emissions of Air blown Pulverized Coal Combustion Technologies (MIT Coal Study 2007)

CO2 Emission vs. Plant Efficiency (HHV)			
Performance	Subcritical	PC/Supercritical	PC/Ultra-Supercritical
Heat Rate Btu/kWe-h	9950	8870	7880
General Efficiency (HHV)	34.3%	38.5%	43.3%
Coal use (106t/y)	1.548	1.378	1.221
CO_2 emitted (106t/y)	3.47	3.09	2.74
CO_2 emitted (g/kWe-h)	931	830	738

Assumptions: 500 MW net plant output; 85% Capacity Factor

An important point to note, however, is the need to incorporate a range of unit sizes to improve the operational flexibility of the grid network and aid grid stability. The proportion of very large units must be related to the size of the national grid because of the disproportionate effect such a unit could have on the distribution system if it were to unexpectedly shut down[5].

Generally, the ultra-supercritical technology is employed in the power unit of which capacity is more than 600MW. However, considering

1) the security and stability of the power transmission grid;

2) the dispatch requirement of the grid, theoretically the maximum capacity of a single power unit interconnecting to the grid is limited to be less than 8%-10% of the total installed capacity.

An ultra-supercritical power plant is therefore not conducive for the power network as it has the potential of resulting in significant power supply instabilities and even collapse.

According to the energy development plan of the GRIDCo, the total installed capacity in 2020 is estimated to be 4700 MW; consequently, the single power unit of the Project would be 7.4%, which is acceptable.

Considering the unit installed capacity of 350MW, the project proposes to adopt the supercritical pulverized coal-fired power plant as more suitable; given

[5] Emission Reduction through upgrade of Coal-Fired Power Plant; Learning from Chinese Experience, Partner Country Series, International Energy Agency OECD/IEA, 2014

that ultra-supercritical technology are more appropriate for larger units. However, the project considers giving serious consideration to adopting the Ultra-supercritical technology in the phase II, which would involve the development of 2X600MW coal fired power generating units.

Boiler Type Selection

Two types of conventional boilers were considered for selection, the pulverized coal (PC) type and the circulating fluidized bed (CFB) type. Considering the high capacity factor of the power plant with annual utilization requirement of 7,000 hours, also the imported coal principally bituminous coal with higher net calorific value (NCV) than 5500kcal/kg and featuring good combustion behaviours the PC boiler with relatively high availability and reliability performance is preferred for the project. Furthermore, "π" shape PC boiler is chosen over "tower" shape PC boiler due to the maturity of the technology, available rich experience and cost saving.

Coal Gasification Option

- Introduction

The integrated gasification combined cycle (IGCC) produces electricity from a solid or liquid fuel. First, the fuel is converted to syngas which is a mixture of hydrogen and carbon monoxide. Second, the syngas is converted to electricity in a combined cycle power block consisting of a gas turbine process and a steam turbine process which includes a heat recovery steam generator (HRSG). The combined cycle technology is similar to the technology used in modern natural gas fired power plants.

Globally, integrated gasification and combined-cycle (IGCC) power plants are a potential option that would make possible lower-emissions, higher-efficiency coal utilization. However, costs must be decreased and reliability must be improved before IGCC is ready for large-scale commercial application.

Figure 4-2 shows the main blocks of a coal based IGCC plant similar to the recent demonstration units. The coal is supplied to the gasifier where it is partially oxidized under pressure (30-80 bar). The plant uses oxygen as oxidant and therefore has an air separation unit (ASU). In the gasifier, which is of the entrained flow slagging type, the temperature may exceed 1500 °C. The high temperature ensures that the ash is converted to a liquid slag with low viscosity, so that it may easily flow out of the gasifier.

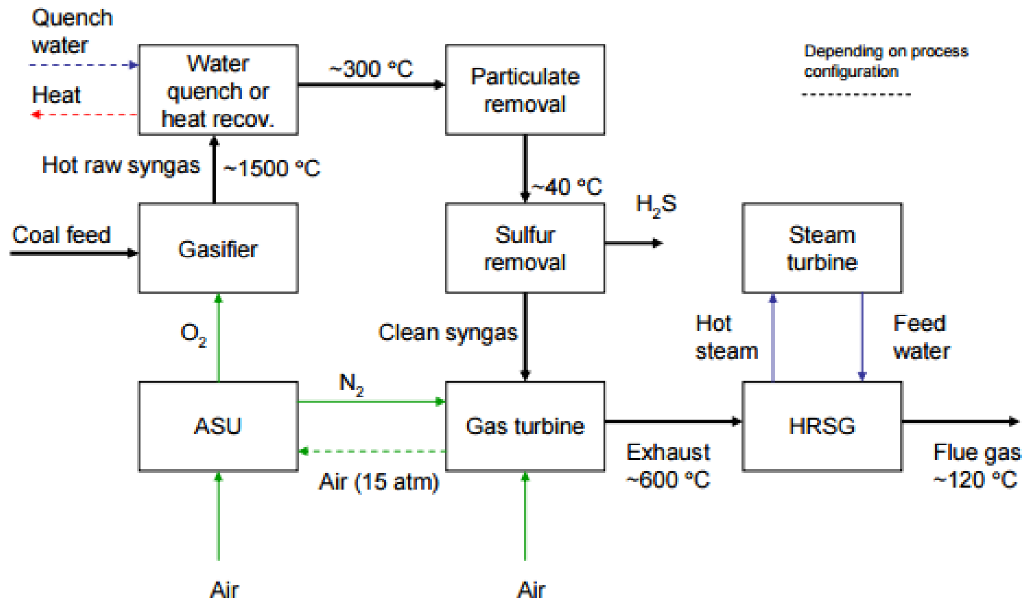


Figure 4-2 IGCC Process

(Source: An Overview of Coal based Integrated Gasification Combined Cycle (IGCC) Technology, September, 2005)

The clean syngas is then fed to the gas turbine for production of electricity. Gas turbines for syngas operation are commercially available. Most of the sensible heat in the hot gas turbine exhaust gas is recovered in the heat recovery steam generator (HRSG) which supplies the steam to a turbine for additional electricity production.

- Development

Worldwide, experiences with coal-based IGCC plants on commercial scale exist from several demonstration projects with government support (see ***Table 4-4***).

Table 4-4 Commercial scale coal/petcoke based IGCC demonstration plants

Project participant/ Plant name	Location	Electric output (net)	Gasifier type (current owner)	Gas turbine	Dates of operation
Southern California Edison/ Cool Water	Barstow, CA, USA	100 MW	GE with heat recovery	GE 7E	1984 - 1988
Dow (Destec)/LGTI	Plaquemine, LA, USA	160 MW	ConocoPhillips E-gas	Siemens SGT6-3000E	1987 - 1995
Nuon/ Nuon Power Buggenum	Buggenum, The Netherlands	253 MW	Shell	Siemens SGT5-2000E	1994 - present
Destec and PSI	West Terre	262	ConocoPhilli	GE 7FA	1995 - present

Energy/ Wabash River	Haute, IN, USA	MW	ps E-gas		
Tampa Electric Company/ Polk Power Station	Mulberry, FL, USA	250 MW	GE with heat recovery	GE 7 FA	1996 - present
Elcogas/ Puertollano	Puertollano, Spain	298 MW	Prenflo	Siemens SGT5-4000F	1998 - present
Sierra Pacific Power Company/Pinon Pine	Reno, NV, USA	99 MW	KRW air blown fluidized bed	GE 6FA	1998 – 2000 (18 start-up attempts, failed to achieve steady state operation)

(Source: An Overview of Coal based Integrated Gasification Combined Cycle (IGCC) Technology, September, 2005)

However, coal based IGCC plants are still not fully commercial. A number of demonstration plants with electric output up to 300 MW have been built in Europe and the US, all with financial support from government. **The main challenges facing the IGCC technology today are capital cost and availability.**

The following is the latest development of large-scale IGCC power plants.

(1) GreenGen Power Station is a 250 MW integrated gasification combined cycle (IGCC) power plant in Tianjin, China. It is the first IGCC facility of such size in China. (Source: Wikipedia)

Construction of the plant began in July 2009 and 72 hours of continuous operation + 24 hours of operation at full load commissioning test successfully completed in November 2012. However, the operating conditions for China's systems are not yet suitable for the commercial application of low-heat-value syngas turbines for IGCC power stations. (Source: Moving Forward with the Huaneng GreenGen IGCC Demonstration, September, 2014)

(2) Edwardsport Plant is an IGCC plant in Edwardsport, Indiana, USA. Duke Energy lists the capacity of the plant as 618 MW. The plant began operation in June 2013, which cost US$3.5 billion to build, after initially being estimated at US$1.9 billion. The plant has experienced significant construction delays, equipment and operational failures, and multiple start-up problems, adding to the already excessive price tag.

As a result of these and other problems with the plant, over the period from June 2013 to March 2014, the plant's costs were 876% higher than if the power had been purchased on the market. Duke Indiana operates in the MISO marketplace where the cost of market purchases over the same period was $33.5 per MWh while Edwardsport came in at a whopping $327.03 per MWH.

(Source: Duke's Edwardsport Boondoggle: Overpaying and Underperforming, February, 2015)

In 2014 the plant generated about 15 percent of capacity in September, 27 percent in October, 71 percent in November and 20 percent in December. In February 2015 the plant's output has rarely risen above 50 percent. (Source: Wikipedia)

(3) The Kemper Project, is a 582 MW electrical generating station currently under construction in Kemper County, Mississippi, USA. The construction of the plant began in 2010. Once operational, the Kemper Project will be a first-of-its-kind electricity plant to employ gasification and carbon capture technologies at this scale.

However, there have been project management problems. The power plant construction has been delayed and is scheduled to open in the third quarter of 2016, more than two years behind schedule, at a cost of $6.6 billion—three times original cost estimate. (Source: Wikipedia)

Globally, integrated gasification and combined-cycle (IGCC) power plants are a potential option that would make possible lower-emissions, higher-efficiency coal utilization. However, costs must be decreased and reliability must be improved before IGCC is ready for large-scale commercial application.

Biomass Co-firing Option

Co-firing coal boiler with biomass has the potential to reduce emissions from coal-fuelled generation, without substantially increasing costs or infrastructure investments. Research evidence has demonstrated that relatively low biomass to coal ratios can result in significant reductions in energy consumption, and solid waste generation, as well as reduced emissions.

However, the nature and chemical makeup of biomass fuels can lead to significant cost increases, maintenance problems, boiler slagging and fouling issues, increased boiler corrosion, and decreased efficiency if biomass use is not very closely managed. The option presents both benefits and challenges.

The potential benefits of co-firing coal boiler with biomass are acknowledged to include:

a) Biomass considered being "carbon-neutral," and its use can have a proportional reduction in GHG emission.
b) The overall emissions of SO_X, NO_X, and mercury, as well as and net GHG

emissions can be reduced with proper fuel selection and management.

c) The addition of biomass to a coal-fuelled boiler not likely to, or will, at worst, have only a minimal negative impact on generation efficiency (depending on fuel preparation measures taken)
d) The possibilities of utilizing pre-existing infrastructure for fossil fuels without additional investment.
e) Low actual fuel costs as biomass is largely considered as "waste.”
f) The costs of biomass compare very favourably to other renewable options

The key challenges of using biomass to co-fire coal fuelled boiler include:

a) The economics of using biomass due to low thermal efficiency, high cost, variable impacts on boiler and milling equipment, and high technical risk.
b) Biomass typically has low bulk energy density, wet and strongly hydrophilic demanding great deal of fuel handling technology compared to its heating contribution.
c) Though fuel costs may be low, comparatively the transportation, preparation, and handling costs for biomass can rapidly exceed total fuel costs for other fossil options.
d) The high potential for increased corrosion rates in boilers due to higher alkali levels in biomass fuel
e) The potential of reduced boiler efficiencies due to high moisture content. Biomass fuels can have as much as 50% moisture.
f) Ash fusion temperatures for most biomass fuels are far less than coal ash fusion temperatures (as low as 750 Celsius vs. over 1,000 Celsius for coal) therefore there is strong possibilities of increased rate and extent of boiler slagging
g) *The negative impacts on fly ash comprehensive utilization due to ASTM specifications requiring that fly ash is derived wholly from coal combustion.*
h) *The potential significant adverse impact on SCR catalysts (deactivation) as indicated by European test.*

Conclusively, co-firing coal boiler with biomass is a potentially valuable to assist reducing greenhouse gas and other gas emissions. Using biomass at low to moderate biomass to coal ratios can produce the best performance enhancements and result in overall life-cycle energy consumption reductions, as well as reduced solid waste generation. However, there are many potential difficulties to utilizing biomass, which can lead to decreased efficiencies, as well as increase costs, maintenance (corrosion, slagging, etc.), and boiler down time if biomass use is not managed very carefully.

Consequently, co-firing the coal fuelled boiler with biomass was not a considered option for the combustion system of this project.

4.2.3 Nitrogen Oxides Emission Control Considerations

SNCR & SCR

a) SNCR

The Selective non-catalytic reduction (SNCR) is process involves injecting either ammonia or urea into the firebox of the boiler at a location where the flue gas is between 850 and 1,050 °C to react with the nitrogen oxides formed in the combustion process. The resulting product of the chemical redox reaction is molecular nitrogen (N_2), carbon dioxide (CO_2), and water (H_2O).

The reduction happens according to (simplified):

$$4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$$

The reaction requires a sufficient reaction time within a certain temperature range, typically 850 and 1,050 °C to be effective. At lower temperatures the NO and the ammonia do not react. At temperatures above 1093 °C ammonia decomposes:

$$4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$$

In that case NO is created instead of removed.

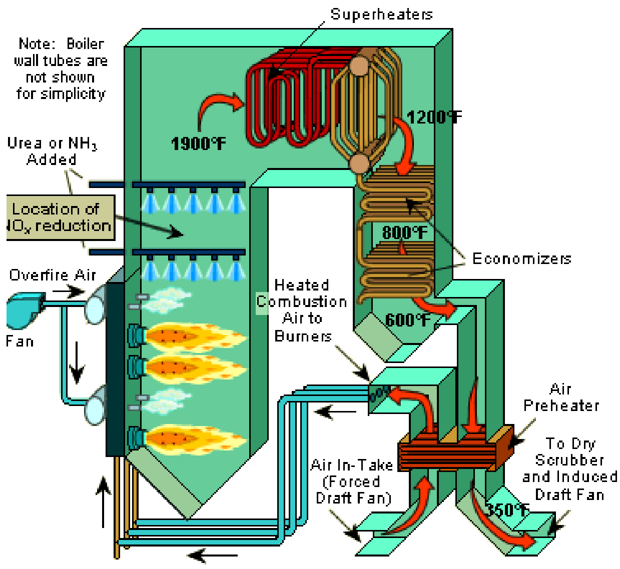


Figure 4-3 Example SNCR System for NOx Control

b) SCR

The SCR process is a catalytic process based on the selective reduction of nitrogen oxides with ammonia or urea in the presence of a catalyst. The reducing agent is injected into the flue-gas upstream of the catalyst. NOx conversion takes place on the catalyst surface at a temperature usually between 170 and 510 °C, by one of the following main reactions.

$$4\ NO + 4\ NH_3 + O_2 \dashrightarrow 4\ N_2 + 6\ H_2O$$
$$6\ NO_2 + 8\ NH_3 \dashrightarrow 7\ N_2 + 12\ H_2O$$

The reaction occurs in the pores of the catalyst bank. The catalyst bank may consist of one or more layers of catalyst for treatment. On the surface of the catalyst, the NOx will be selectively reduced by reacting with ammonia in the presence of oxygen to form harmless byproducts, water and nitrogen (H_2O & N_2).

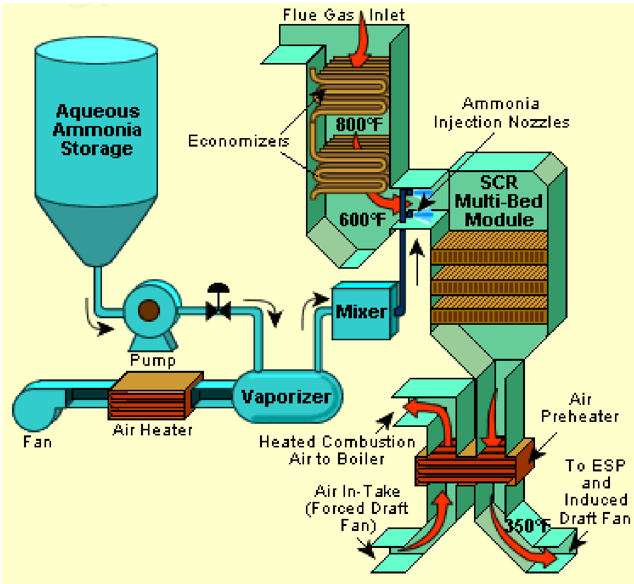


Figure 4-4 Example SCR System for NOx Control

c) Comparison of the Two Technologies

Table 4-5 Comparison between SNCR and SCR

Item	**SNCR**	**SCR**
Reducing Agent	Ammonia, Urea	Ammonia, Urea
Operating temperature	850 – 1050 °C	350 – 450 °C (high-dust) 170 – 300 °C (tail-end)
Removal Efficiency	30 – 50 %	80 – 95 %
System	Simple	Complicated
Plant Capital Cost Increase	1-2%	4-9%

Consumption as % of electric capacity	0.1 – 0.3	0.5
Catalyst	Operates without using catalysts	Life of catalysts has been 6-10 years, and catalysts may contain heavy metals. Proper handling and disposal/ recycle of spent catalysts is needed.

With the adoption of low NOx burners, the concentration of NOx in the flue gas is estimated to be less than 350mg/Nm^3.

In order to achieve the requirement of 200mg/m^3 of NOx emission, removal efficiency of 42.8% should be expected during normal operation. Although the theoretical efficiency of SNCR is 30-50%, the practical efficiency proves to be 30-35% according to operation experiences. It is therefore SCR system is planned for the NOx reduction.

SCR Reductant

Several reductants are currently used in SCR applications including anhydrous ammonia, aqueous ammonia or urea. All those three reductants are widely available in large quantities.

Pure anhydrous ammonia is extremely toxic and difficult to safely store, but needs no further conversion to operate within an SCR. It is typically favoured by large industrial SCR operators because of low operation cost. Aqueous ammonia must be vaporized in order to be used, but it is substantially safer to store and transport than anhydrous ammonia. Urea is the safest to store, but requires conversion to ammonia through thermal decomposition in order to be used as an effective reductant.

Currently none of these reductants are produced in Ghana and have to be imported from other countries like Europe, India or China. Considering the safety of transportation, handling and storage, Urea is selected as the reductant of the SCR process for the project.

4.2.4 Flue Gas Desulfurization (FGD) Considerations

There are two basic technologies for controlling SOx emission. The two systems, wet limestone gypsum FGD and seawater FGD are presently matured applications of desulfurization technology. The details of the technological processes are presented as following:

Limestone-Gypsum FGD

Limestone is used in most cases as the sorbent, because it is available in large amounts in many countries and is cheaper to process than other sorbents. ***Figure 4-5*** shows a typical flow diagram of a recent type of wet Limestone-Gypsum FGD system.

The flue-gas leaving the particulate control system usually passes through a heat-exchanger and enters the FGD absorber, in which SO_2 is removed by direct contact with an aqueous suspension of finely ground limestone slurry. Fresh limestone slurry is continuously charged into the absorber. The scrubbed flue-gas passes through the mist eliminator and is emitted to the atmosphere from a stack.

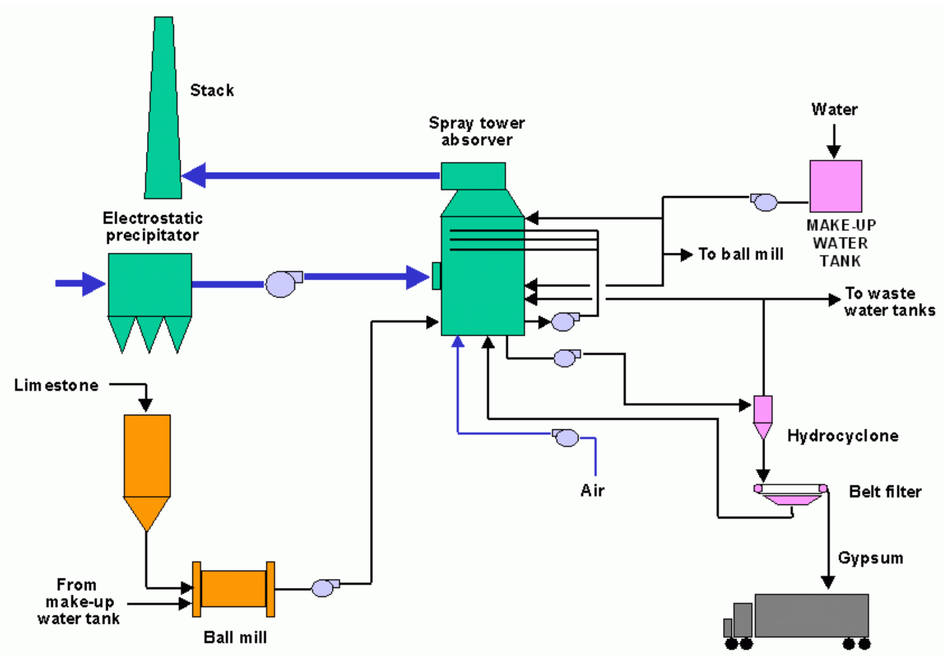


Figure 4-5 Basic Principle of Limestone-Gypsum FGD Process

In forced oxidation mode with a pH range of 5 to 6, which is common in wet limestone scrubbers, the chemical reactions are as follows:

$$SO_2 + H_2O \text{-->} H_2SO_3 \quad (1)$$

$$CaCO_3 + H_2SO_3 \text{-->} CaSO_3 + CO_2 + H_2O \quad (2)$$

$$CaSO_3 + \frac{1}{2}O_2 + 2H_2O \text{-->} CaSO_4 \bullet 2H_2O \quad (3)$$

$$CaCO_3 + SO_2 + \frac{1}{2}O_2 + 2H_2O \text{-->} CaSO_4 \bullet 2H_2O + CO_2 \quad (4)$$

The wastewater produced is collected in the tank and then delivered to the wastewater treatment system. The main reactive product is calcium sulphite, which is oxidized to calcium sulphate later, and then it is withdrawn from the absorber and are sent for dewatering and further processing into gypsum. The gypsum can be sold to the building materials market, or collected for further disposal or landfill.

Seawater FGD

Seawater FGD utilizes seawater's inherent properties to absorb and neutralize sulphur dioxide in flue-gases. If a large amount of seawater is available near a power plant, it is most likely to be used as a cooling medium in the condensers. Downstream of the condensers the seawater can be re-used for FGD. The basic principles of the seawater FGD process can be seen in ***Figure 4-6***.

The flue-gas from the power plant leaves the dust collector, normally an electrostatic precipitator. The flue-gas is then fed to the SO_2 absorber, where it comes into contact with controlled proportion of the seawater, taken from the cooling water outflow of the steam turbine condenser. Due to the presence of bicarbonate and carbonates in the seawater, the sulphur dioxide of the flue-gas is absorbed. The acidified absorber effluent is mixed with additional seawater to ensure that the pH is at optimal level for the oxidation process. The introduced air forces the oxidation of the absorbed sulphur dioxide from bisulphite to bisulphate and removes dissolved CO_2. The water would be nearly saturated with oxygen and the pH value would be restored to neutral before the seawater is discharged back to the sea.

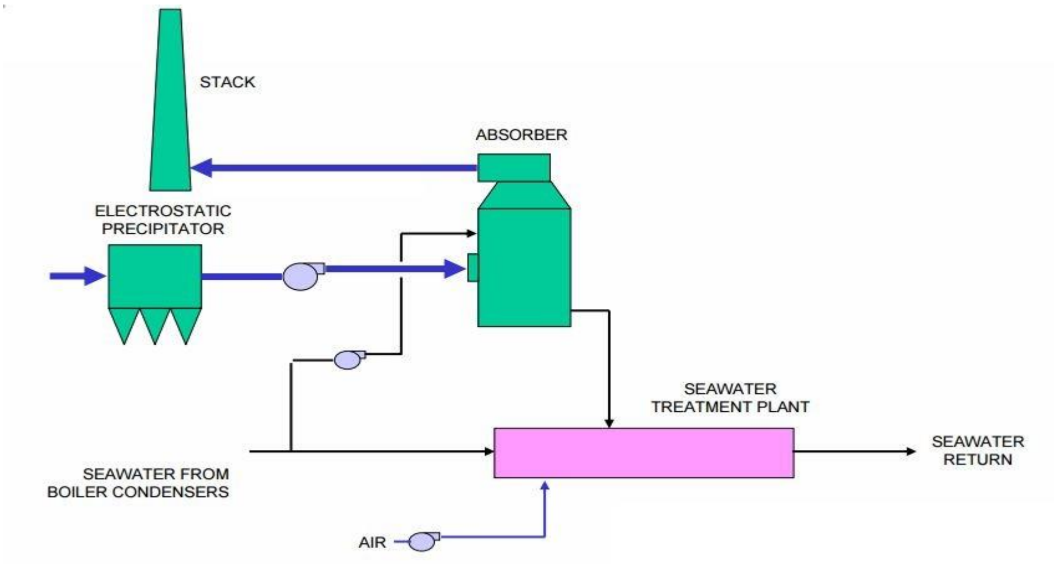


Figure 4-6 Basic Principle of Seawater FGD Process

The process is based on the following chemical reaction:

$$SO_2 + 2HCO_3^- + \frac{1}{2}O_2 \text{-->} SO_4^{2-} + 2CO_2 + H_2O$$

After absorbing the SO_2, the acidified seawater collects in the absorber sump and flows by gravity to the seawater treatment plant (SWTP). The acidified absorber effluent is mixed with the rest of the cooling water in a special mixing unit in the front section of the SWTP and subsequently oxidized. Ambient air is blown into the seawater using heavy-duty industrial fans. The SO_2 will then be converted to sulphate (SO_4^{2-}), the absorbed SO_2 is oxidized to harmless sulphate ion, a natural constituent of seawater. The seawater will be nearly saturated with oxygen and the pH 6 level will be adjusted.

<u>Comparison of the Two Technologies</u>

The two FGD methods are both mature technologies and are widely used all over the world. A detailed comparison between the Limestone-Gypsum FGD and Seawater FGD is described in ***Table 4-6***.

Table 4-6 Comparison between Limestone-Gypsum FGD and Seawater FGD

Item	Limestone-gypsum FGD	Seawater FGD
Absorbent	Limestone	Seawater
Site Applicability	More widely used because of availability of the limestone	Only applicable for power plants located near the coast
Coal Applicability	Applicable for high Sulphur content	Only practical for low Sulphur coal (≤1.5%)
Removal Efficiency	limestone FGD can achieve removal efficiency of 85 to 98%	Removal efficiency up to 90%
System	Complicated	Simple
Plant Capital Cost Increase	11-15%	7-10%
Operation Cost	Use 1-1.5% of electricity generated	Use 0.8-1.6% of electricity Generated
Operation Reliability	The limestone slurry will cause frequent blockage and abrasion problems in pipelines, and the by-product gypsum usually cause scaling problems.	Few problems in the operation process due to the simple system.
By-product	Gypsum as a saleable by-product or waste	Simple process, no by-product (wastewater or solid waste)
Wastewater	Desulfurization wastewater	—

Generally, the selection of FGD technology depends on the capacity of the plant, fuel properties, site conditions, and the cost and availability of reagent as well as by-product disposal and utilization.

According to the location of the project, which is near the coast and the coal fuel of low sulphur content, both FGD technologies are suitable for the desulphurization process. Either FGD technology would yield reduced emission level of SO_2 to 200mg/m^3, conforming to the best standard of the IFC and the World Bank Group.

Consequently, the seawater FGD is the preferred option considered for the project taking into account the following issues:

a) The subsystems of Limestone-Gypsum FGD are complicated, especially the limestone slurry grinding, storage and supply system, and gypsum dewatering and handling system. According to the operation and maintenance experiences, the limestone slurry would cause frequent blockage and abrasion problems in pipelines, and the by-product gypsum usually causes scaling problems. These malfunctions and higher maintenance demands can significantly reduce the reliability of the FGD system, consequently threatening the overall security and reliability of the whole power units.

b) The high investment requirements for the Limestone-Gypsum FGD due to the complicated subsystem and the high maintenance cost resulting from the frequent malfunctions as mentioned above.

c) Generally, a typical 2x 350MW supercritical power plant will produce about 120, 000 tons of by-product gypsum per year with Limestone-Gypsum FGD technology. However, currently the utilization or processing of the gypsum is not developed in Ghana, which implies a large tract of land would be required for gypsum disposal or landfill, creating further environmental concerns.

In conclusion, Seawater Flue Gas Desulfurization (FGD) technology is adopted for this project as opposed wet limestone gypsum FGD. The project is located by the sea, coal sulfur content <1%, in this phase and therefore seawater FGD is favourable.

4.2.5 Carbon Dioxide Emission Control Considerations

Carbon Capture and Storage (CCS) Technology

Carbon Capture and Storage is a potential means of mitigating the carbon contribution from fossil fuel emissions to global warming phenomenon.

Carbon capture and storage (CCS) is the process of capturing waste carbon dioxide (CO2) from large point sources, such as large industrial plants, transporting and depositing it into storage site, normally an underground geological formation to prevent release of large quantities of CO_2 into the atmosphere.

The process consists of three stages identified as capture, transport, and safe underground storage, which is shown in ***Figure 4-7***.

a) *Capture* involves removing or separating the carbon dioxide from coal and gas power plants. There are three types of capture namely post-combustion, pre-combustion and oxyfuel combustion, which can capture 90% of carbon dioxide emissions.

b) *Transport* involves compressing the carbon dioxide and transporting to a suitable storage site usually via pipelines or by ship for offshore carbon dioxide transport.

c) *Storage* is the injection of the carbon dioxide into suitable storage site deep below the ground. The storage site must be a geological formation that ensures safe and permanent storage, which may include depleted oil & gas fields, or deep saline formations.

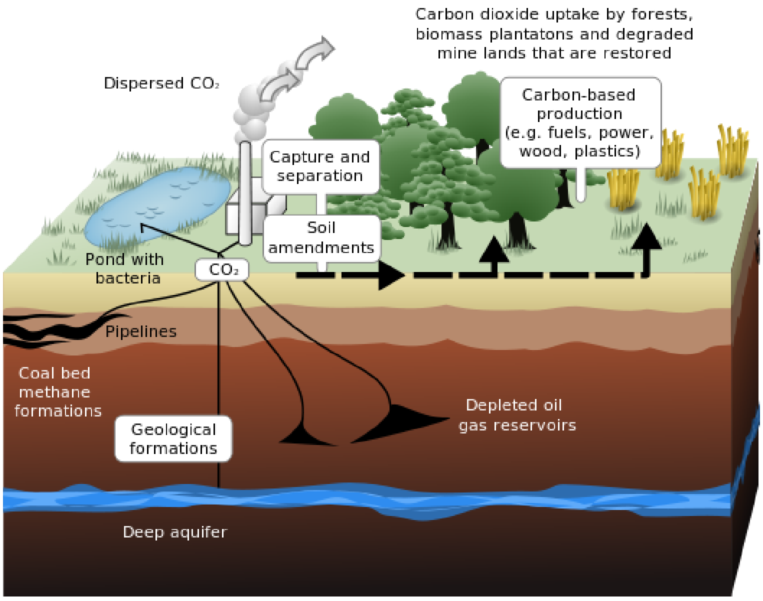


Figure 4-7 Schematic Illustration of Both Terrestrial and Geological Sequestration of Carbon Dioxide Emissions from a Coal-fired Plant

The technology may be applied in different industrial areas such as chemical production, fertilizer production, hydrogen production, iron and steel production, natural gas processing, oil refinery and power generation.

However, globally there are 15 large-scale CCS projects in operation with capacity to capture up to 28 million tonnes of CO2 per year (Mtpa). There are also additional seven under construction[6]. It is evident that the scale of development during the years has been rather sluggish as shown in ***Figure 4-8***.

[6]Global Status of CCS SUMMARY REPORT, 2015 by Global CCS Institute

Figure 4-8 Large-scale CCS Projects in Operation by Year

Source: http://hub.globalccsinstitute.com/sites/default/files/publications/196843/global-status-ccs-2015-summary.pdf

Of these projects only one CCS operation is within the power sector and two are under construction, with several still at the planning phase. These are identified projects to include:

Table 4-7 Power Plant CCS Projects (In Operation or under Construction)

Project Name	Location	Feedstock	Size MW	Capture Process	CO2 Fate	Status
Boundary Dam	Saskatchewan, Canada	Coal	110	Post Combustion Capture	Enhanced Oil Recovery	Operational October 2014
Kemper County	Mississippi, USA	Coal	582	Pre Combustion Capture	Enhanced Oil Recovery	Under Construction
Petra Nova WA Parish	Texas, USA	Coal	240	Post Combustion Capture	Enhanced Oil Recovery	Under Construction

Source: https://www.globalccsinstitute.com/projects/large-scale-ccs-projects
http://sequestration.mit.edu/tools/projects/index_capture.html

Typically, the cost of capturing and storing carbon dioxide is indicated at US$60 per ton, corresponding to an increased electricity price of about US$ 0.06 per kWh (based on typical coal-fired power plant emissions of 0.97 kg (2.13 lb) CO_2per kWh[7].

[7]Science, 27 February 2009, Vol 323, p. 1158, "Stimulus Gives DOE Billions for Carbon-Capture Project

The high price build up may be attributed to (1) the high energy requirements of capturing and compressing CO_2, which significantly increases the operating costs of CCS-equipped power plants; (2) the additional investment and capital costs resulting from the increased fuel requirement of the plant by some 25% for a coal-fired plant and about 15% for a gas-fired plant and operational cost; (3) Pre-commercial CCS demonstration projects are likely to be more expensive than mature CCS technology.

The net cost has therefore been estimated to increase the costs of energy from a power plant with CCS by 30–60%, depending on the specific circumstances. Generally, there is also the risk of the difficulties and uncertainties of such long term prediction of the security of submarine or underground storage and the risk of CO_2 leaking into the atmosphere[8]. Other risk factors include tear and leakage of injection pipes due to high pressure and the potential of causing earthquakes, which potentially could undermine carbon storage schemes, leading to the leakage of CO_2. Therefore, it is important that continued research is carried out on the potential for induced seismicity from the injection of carbon dioxide into underground storage sites.

Therefore, CCS is not considered for this project although the technology is the most promising technique for dramatically controlling CO_2 emissions from coal-fired power plants. The reasons including:

a) The technology is not significantly matured for widespread commercial application (consumption).
b) The high costs associated to the operation of CCS facility which adds considerably, as much as 60% to the final cost of electricity.
c) The uncertainty of the potential risk regarding long term storage insecurity and the possible CO_2 leak into the atmosphere, the potential of causing earthquakes, which undermines the carbon storage scheme.

CO_2 Control Intervention for the Project

The CO_2 emission control interventions considered for the project include the following:

a) Adoption of Super-critical coal fired power generating technology
b) Carbon sequestration potential of VRA Reforestation Programmes within Volta lake
c) Offsets from VRA's Combined Cycle Projects
d) Offsets from VRA's and SEC's Renewable Energy Programmes

[8]Phelps, J; Blackford, J; Holt, J; Polton, J (2015), "Modelling Large-Scale CO_2 Leakages in the North Sea", International Journal of Greenhouse Gas Control

(Solar/Wind)

e) Carbon Accounting Programme beginning 2016

- Offsets from VRA Combine Cycle Projects
  a) Conversion of the 220 MW TICO Plant into a 330 MW CC Plant (Operational)
  b) Expansion of the existing 110 MW SC TT1PP into a 330 MW CC Plant (Env. Permit issued / Financing stage)
  c) Conversion of 220MW SC KTPP to 330 MW CC resulting in 400,000 tons CO_2e savings (EIA/ FEED ongoing)

- VRA's Renewable Energy Development Programme Phase 1:
  a) 150 MW Wind Power Projects
  b) Planned 75MW Wind Power Project 1 (Anloga Extension) in the Volta Region (EIA / FEED ongoing)
  c) Planned 75MW Wind Power Project 2 (Wokumagbe and Goi) in the Ada West District (EIA/ FEED ongoing)
  d) 14.5 MW Solar Power Projects
  e) 2.5 MW Navrongo Solar Power Plant (Operational)
  f) 8 MW Solar Power plant in Kaleo in the Upper West Region (Env. Permit issued / financing stage)
  g) 4 MW Solar Power plant in Lawra in the Upper West Region (Env. Permit issued / financing stage)

- SEC's Renewable Energy Development Programme
  a) Planned 50MW Wind Power Project in the Greater Accra Region (Feasibility Study ongoing)

- VRA Carbon Sinks
  a) Planted 3,193 hectares of forest cover as at close of 2015 and contributing between 300,000 – 730,000 tons of Carbon sink
  b) Planned sequestration value of 6,000 – 14,000 tons annually to the existing sink from 2016 – 2020
  c) Planned sequestration value of 96,000 – 230,000 tons by 2020 under the Forest Investment Program (VRA proposal completed for submission to the Forestry Commission)

4.2.6 Seawater Cooling Considerations

There are three basic alternatives for cooling thermal power plants, which include Air-cooled Condenser System, a Cooling Tower System and Direct Circulating (Once Through) Cooling Seawater scheme.

The coal-fired power plant considered two basic cooling options, which are the Cooling Tower System and Direct Circulating Cooling Seawater Scheme.

The cooling tower system or closed-loop system reuses cooling water in a second cycle. The process involves cooling streams of small water droplets by current of air created by large fans. The cooled water is then returned to the condenser to continue the cooling cycle. The cooling effect is achieved through evaporation of some of the cooling seawater. Consequently, a part of the water is lost in the process and make up is required to maintain the quantity of water. The cooling tower system only withdraws water to replace water lost through evaporation in the cooling tower. Consequently, such systems have much lower water withdrawals but also tend to have appreciably higher water consumption. The temperature of the return water is generally 10^0 C higher than the direct-cooled option.

Direct Circulating Cooling Seawater Scheme or Once-through circulation system takes water from nearby source (e.g., rivers, lakes, aquifers, or the ocean), circulate it through pipes to absorb heat from the steam in condensers, and discharge the warmer water to the source. Once-through systems were initially the most popular because of their simplicity, low cost, and the possibility of siting power plants in places with abundant supplies of cooling water. The system is currently widely used.

Direct cooling by circulating seawater is achieved by continuously supplying seawater from the sea to the condenser to cool the steam from the turbine and then returned to the sea (Once through cooling).

Comparison between the use of seawater cooling tower and direct once through circulation cooling system presents benefits of using the once through cooling system and the disadvantages of using the seawater cooling tower scheme. These are presented as following:

Benefits of using once through circulation cooling scheme:

According to experience empirically gathered from the Takoradi International Company's once through cooling system to serve T1 and T2, the once through circulation cooling brings considerable benefits compared to using seawater cooling tower. This is attributed to the lower temperature of the cooling water leading to improved cooling of the steam turbines (higher thermal efficiency) and increased outputs of the steam turbines. Colder water cools the steam more effectively and allows more efficient electricity generation. It has been stated that the benefits are centered on improving generation efficiency, increasing electricity supply and limiting air emissions and climate change.

These benefits have been illustrated as following:

a) Increased outputs of the steam turbines as improved cooling leads to better steam turbine performance thus providing additional output energy without any increase in fuel consumption. Generally, improved cooling allowed the power plants to operate at an overall higher efficiency. Consequently, the once through circulation cooling would contribute to increased output efficiency of the power plant. In this regard, additional energy is available creating additional capacity to supply additional population and representing additional installed capacity.

b) The increased energy output of the turbines without increased fuel use creates reduction in CO2 emissions per unit power output and also the displacement of additional thermal generation requirement to supplement installed capacity creates further reduction in flue gas pollutants emissions and CO_2 emission. CO_2 reduction can be significant and may be estimated by the calculation from thermal efficiency increase and generation displacement.

c) Reduced maintenance costs of all civil and mechanical steel components, resulting from the elimination of seawater cooling towers, which causes salt spray and corrosive saline air conditions.

d) Noise reduction due to the absence of cooling tower fans.

Disadvantages of using seawater cooling tower scheme:

a) Lower efficiency during heat exchanges
b) Efficiency further reduced by high temperature and humidity
c) Causes salt spray and its environmental implications
d) Require large water pumps and large fans on the cooling tower creating additional power consumption requirements.

Considerations at the feasibility stage identified efficiency, environmental consideration, location of the plant and economics of the plant development and operationas the key advantage factors; therefore, proposing a once through seawater cooling system for the coal-fired power plant, which offers considerable benefits over the cooling tower system.

4.2.7 Coal Storage

Coal storage facilities offer two basic alternatives identified as the open yard storage system and the close yard storage system (See ***Figure 4-9***). As the name depicts the open yard storage is not enclosed compared with the close yard storage which is significantly enclosed to prevent wind disturbance, which may cause fugitive coal dusts flying all around.

Open Coal Storage Yard

Partially Closed Coal Storage Yard

Totally Closed Coal Storage Yard

Figure 4-9 Comparison of Different Coal Storage Yards

Closed coal yard storage scheme is proposed for this project. Despite enclosed system is much more expensive than the open system, a close yard system is chosen over an open yard system primarily to prevent or control fugitive coal dust from escaping into the environment.

4.3 Fuel Option Considerations

4.3.1 Coal Type Selection

The principal source of coal fuel is considered to be South African thermal coal (with high Net Calorific Value and low sulfur content). Coal from one Coal Mine of South Africa will be used as the design coal, the poor quality 47101 coal sample from another coal mine of South African will be used as the check coal 1 and coal from a coal mine of Columbia will be used as check coal 2.

The coal type recommended for the project is bituminous coal and the indicative coal specifications are provided in ***Table 4-8***.

Table 4-8 Indicative Coal Specification

Coal Source / Item	South Africa 1	South Africa 2	Columbia
Total Moisture (arb)	12% max	7-15%	11.4% typical
Inherent Moisture (adb)	3.5% typical	3-8%	4.5% typical
Ash (adb)	15% max	12-25%	15.5% typical
Volatile Matter (adb)	22% min	20-30%	34.8% typical
Total Sulphur (adb)	1.0% max	0.5-1.0%	0.75% typical
Net Calorific Value (arb)	5000-6000 kcal/kg	4800-6000 kcal/kg	5600kcal/kg typical

4.3.2 Diesel Oil Specification

Plasma ignition system is proposed to be adopted for boiler start-up and low-load operation assistance, taking consideration of its great operation cost saving advantage.

However, to guarantee the reliability and availability of the power plant, diesel fuel system is prescribed as a back-up solution. The No.0 light diesel oil can be selected for ignition and combustion-supporting fuel. This would be delivered by tanker truck to the site. Two oil tanks with a volume of 2x300m^3 are to be built for the storage the diesel, which will be able to meet the demand of boiler ignition and combustion-supporting.

The light diesel oil specification is as following:

Table 4-9 The Light Diesel Oil Specification

No.	Item	Unit	Value
1	Kinematic Viscosity in Centistokes at 20 Deg.C	mm^2/s	3.0~8.0
2	Pour Point	℃	0
3	Flash point (Closed cup)	℃	≥55
4	Sediment by weight	%	nil
5	Total sulphur content	%	≤0.2
6	Water content by weight	%	nil
7	Ash Content by weight	%	≤0.02
8	Net Calorific Value	kJ/kg	41800

4.4 Alternative Site Considerations

The Project prefeasibility study evaluated five potential sites for considerations of situating the proposed integrated coal-fired Power Plant and Coal Handling Terminal, with overall planned installed capacity of 2,000 MW. The five sites included Domunli Site (Site 0), Akwidaa Site (Site 1), Ekumfi Site (Site 4), Atwereboana Site (Site 2) and Dutch Komenda Site (Site 3), and their geological positions are shown in ***Figure 4-10***.

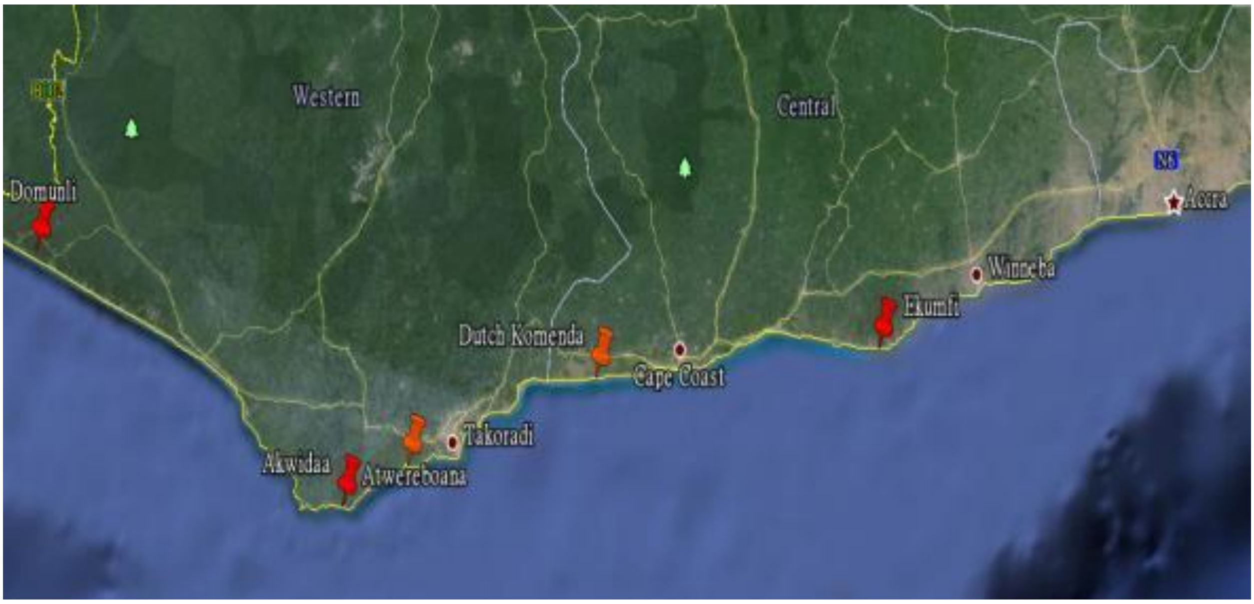


Figure 4-10 Map of Potential Sites

On the basis of site investigation on the 5 potential Sites, 2 sites were selected and considered for detailed locational evaluation and analysis. The proposed sites are Akwidaa Site (Site 1) and Ekumfi Aboano Site (Site 4).

The basis of screening, evaluation and final selection of suitable site considered the following:

a) Well-coordinated relationship between the project and the environment around the site recognizing conditions for sustainable development;

b) Reasonable arrangement plan of relevant equipment and buildings to conserve land resources on the premise, whiles facilitating related O&M activities;

c) Vertical arrangement of physical structures and facilities to reduce site earthworks and keeping cutting and filling quantities reasonably balanced.

The summary technical evaluation and comparison of the 5 sites are presented in ***Appendix 6: Sites Technical Evaluation and Comparison***.

4.4.1 Akwidaa (Site 1)

The Geographic Coordinates of the site are specified as: N 4°45'37.20", E 1°59'51.00". It is 30km south-west of Takoradi, 2km east of Akwidaa and more than 1.5km away from the village around. The access road of length 0.2km would connect a 6km branch road of clay pavement joining the Takoradi-Agona road.

The available land is 3km long, extending westwards to a stream and eastwards to a hill with a width of 2km from the seashore to the north with a proposed plant land of 29 X $10^4 m^2$. The site area can satisfy the construction requirements of the proposed 2,000 MW power plant, living area, ash yards and construction area. There would be no demolition within the boundary of the site. Excavation requirement is estimated as 30 X $10^4 m^3$ and the filling demand is estimated as 40 X $10^4 m^3$.

The existing main features of the site are lush vegetation with many palm trees, shrubs and weeds. The terrain is relatively flat and ground elevation is from 3 to 10m. The existing land uses are predominantly for farming purposes. Other land uses are for both domestic residential and commercial facilities. The proposed area for the development of the coal-fired power plant is relatively developed with a number of physical structures and settlements especially commercial tourism facilities including beach resorts. This situation could represent more complexities and challenges in respect of land acquisition processes and resettlement requirements. A no development scenario would likely see the on-going development continuing.

According to the available marine maps, the depth contour of -10m is about 400m away from coastline and the depth contour of -16.5m is about 1600m away from coastline. There is an outward sandy coast in the west and a headland in the east. The coastline has an oblique angle to prevailing wave direction, causing significant alongshore sediment transportation from west to east. Consequently, the layout of breakwater would have significant impact on shoreline stability. Similarly, the impact of alongshore sediment transportation on the nearby channel entrance should be noticed.

The extreme highest tide level in the sea area near the site is 2.6m with Return period of 100 years; and the extreme wave height of 3.4m has Return period is 50 years. The site is not affected by the Atlantic Ocean tide which has Return period of 100 years. However, the site may be affected by the local watershed water catchment from north and east.

Akwidaa has been recognized as one of the coastal communities most vulnerable to climate and other stressors in the Western Region. The hydrology and oceanography of the area indicate thatthe coastline itself offers a distinctive marine-estuarine environment, with extensive mangroves and a lagoon called “Nana Ezile” draining the community into the sea. The lagoon divides the community into two with the Old town (downhill) experiencing occasional flooding.

Akwidaa has an extensive network of mangrove forest due to the open lagoon "Nana Ezile" which stretches up to 2km inland. Not far from Akwidaa is the Cape Three Point Forest Conservation Reserve. The proximity and sensitivity of this forest reserve may pose questions over its long term conservation roles with a nearby power plant.

The prevailing situation within Akwidaa community shows prevalence of alongshore sediment transportation and history of major flooding especially along the shoreline. The flooding has already caused the resettlement of the inhabitants and emergence of a new community uphill referred to as Akwidaa New town. It was acknowledged that the site for the old chief's palace currently lies in the middle of the shoreline. In this regard, construction of the coal handling terminal is expected to have major environmental impacts and implications on the shoreline stability.

The site is recognized turtle beach preservation. From the consultations, the fishermen confirmed the prevalence of sea turtle and nesting activities at the shoreline. and the existing huge mangrove along the coastal area also provides significant environmental concerns.

Access road to the site is significantly hilly and rocky and in poor condition. The road therefore presents harsh road conditions with subsequent development challenges.

For the purpose of power evacuation, a new 2x50 kilometres 330kV transmission line is required to connect the power plant to the Aboadze 330kV substation. Power evacuation is toward the east. This also presents considerable issues in relation to the expanse of land use alternative and conservation and acquisition of right of way for the transmission line and compensation arrangements.

Power supply for construction purposes can be accessed from local grid near the Takoradi-Agona Road (linear distance is 14km) while water supply would be from underground water or city water nearby. Construction material source is at the north-east of the site about 90km away and other building materials may have to be conveyed through Takoradi Port.

4.4.2 Ekumfi Aboano (Site 4)

The Geographic Coordinates of the site are specified as: N 5°12'41.44", W 0°49'51.00". The site is 78 km west of Accra and 50 km east of Cape Coast and also about 0.6 km away from adjacent village. A 0.3km access road would connect a new 2.8 km branch road developed to the north of the plant, which connects to 15km two branch roads to the north of the site linking Accra-Cape Coast main road.

The available land measures 2.0 km from west to east, and stretches 2.0 km northwards from the southern seashore with a proposed plant land of 29 X 10^4m^2. The land area can satisfy the construction of the power plant, living area, ash yards and construction area. There would be no demolition within the boundary of the site. Excavation requirement is estimated as 250 X 10^4m^3 and the filling demand is estimated as 260 X 10^4m^3.

The current situation shows an undeveloped land with good vegetation on the surface lying in hilly areas with elevation of 3 m to 30 m. The existing land uses are predominantly for farming purposes. Other land uses such as residential and commercial facilities are barely in existence. Natural moderate weathered granite can be taken as natural foundation bearing layers for the buildings. Zoning of the area is undetermined; however, the site accords with urban planning. A no development scenario is expected to reflect increased land uses for residential and other commercial activities including tourism facilities in the near future.

The shore is characterized by rocky coastline with cliffs and it includes a small portion of sandy beach. This presents a natural coastal geomorphology suitable for the project. According to the existing marine charts, the depth contour of -10m is about 900m away from coastline and the depth contour of -16.5m is about 4000m away from coastline. The bottom substrate consists mainly of medium-coarse sand with considerable alongshore sediment transport rates showing eroded coast in general.

The site is located in the hilly area and the terrain is high-pitched. There is a small seasonal flash floods ditch with small drainage area on the west side of the site. There is no water in the ditch during dry season but gets flooded in the rainy season. To the south of the site is the Atlantic Ocean, East-west coastline is about 8m above the sea level. The extreme highest tide level in the sea area near the site is 2.6m with Return period of 100 years; and the extreme wave height of 3.4m has Return period is 50 years. The preliminary judgment is that the site is not affected by the Atlantic Ocean tidewater with Return period of 100 years. However, the site may be affected by the local watershed water catchment from the north.

There exist 330kV power lines along the Accra-Cape Coast road, which is suitable for the power evacuation to the local transmission line. A new 330kV transmission line connecting the existing 330kV line at the north of the site would be required running 2x15 km. Power evacuation is towards south, turning west and then north to connect. There is adequate space available.

Power supply for construction may be accessed from local residential network or it can be connected from the power transmission line near the Accra-Cape Coast road (linear distance is 20km). Water supply for construction may use nearby urban water supply.

Constructional materials can be obtained from existing quarries, which are situated within 40 km proximity. However, the local rock material of the site, which is granite with elevation above design requirement, represent significant source of local quarry and constructional materials for the construction works.

According to Geologic structure and evaluation of stability of the site, there is no active fault within the site. It is preliminarily considered that the plant site is located in comparatively stable area, which is suitable for building of power plant.

According to seismic effect information collected, it is preliminarily advised that the design basic acceleration of ground motion value is 0.15g, with 10% probability of exceedance in 50 years, corresponding seismic fortification intensity is 7 degree.

In conclusion, the Site belongs to a relatively stable geologic unit, and it is fit for building a power plant. The average maximum water table is more than 20m within this site. Flooding Risk Assessment indicated that Ekumfi, located in a hilly area has high-pitched terrain. The ground cover comprises of shrubs. The ground elevation is about 7 to 24m. There is a small seasonal flash floods channel with small drainage area on the west side of the site; there is no water in the channel during the dry season but gets flooded in the rainy season. To the south of the site is the Atlantic Ocean. East-west coastline is about 7m above the sea level; the preliminary judgment is that the site is not affected by the Atlantic Ocean swell with a return period of 100 years. The site may be affected by the local watershed water catchment from the north.

4.4.3 Preferred Site

Considering the geophysical characteristics and site advantages and disadvantages in relation to the project development of Akwidaa (Site 1) and Ekumfi (Site 4) and the associated environmental impact implications, the project has proposed situating the 2X350MW supercritical coal-fired power plant at Ekumfi (Site 4) as the preferred site for the proposed development.

Table 4-10 Summary Site Evaluation

Akwidaa	**Ekumfi**
Advantages	Advantages
• The sea is not occupied. • A small volume of earthworks required • The site is relatively flat, and the natural level is proper for the plant layout. • Good sea depth.	• The native chief and people support the project. • The ground is stable with high load bearing strength, no pile foundation expected so far. • Access road to be paved and broaden is shorter, about 4km. • Good peripheral infrastructure and supporting condition. • Not obvious siltation issues. • 330kV transmission line is shorter. • Water intake pipes are shorter. • The coal conveying gallery is shorter.
Disadvantages:	Disadvantages:
• 330kV transmission line is longer. • The foundation adopts piles. • Water intake pipes are longer. • The access road condition is bad, 10km access way need to be paved and broaden. • The seashore is turtle beach preservation area • The coal conveying gallery is longer.	• A large volume of earthworks required • The sea will be occupied. • The rural environment will change.

5 DESCRIPTION OF EXISTING ENVIRONMENT

The chapter provides summary description of the resources and environmental baseline conditions (including the physical, biological, socio-cultural and economic) of the proposed site including the immediate adjoining land uses and zoning status, which provide the basis for the assessment of impact.

The proposed site is located in Ekumfi Aboano in the Central Region, Ghana, which is shown in ***Figure 5-1*** and ***Figure 5-2*** (5°12'43.07"N, 0°49'52.49"W).

Consequently, the proposed project would likely affect a specified area of its location. This area likely to be influence by the project determines the project's Area of Influence (AOI).

The area influence is defined by IFC (IFC Performance Standard 1 (OP.4.01, Annex A, para 6)) as the area likely to be affected by the project, including all its ancillary aspects and associated facilities, such as power transmission corridor, pipelines, canals, tunnels, relocation and access roads, borrow and disposal areas, and construction camps, as well as unplanned development induced by the project[9].

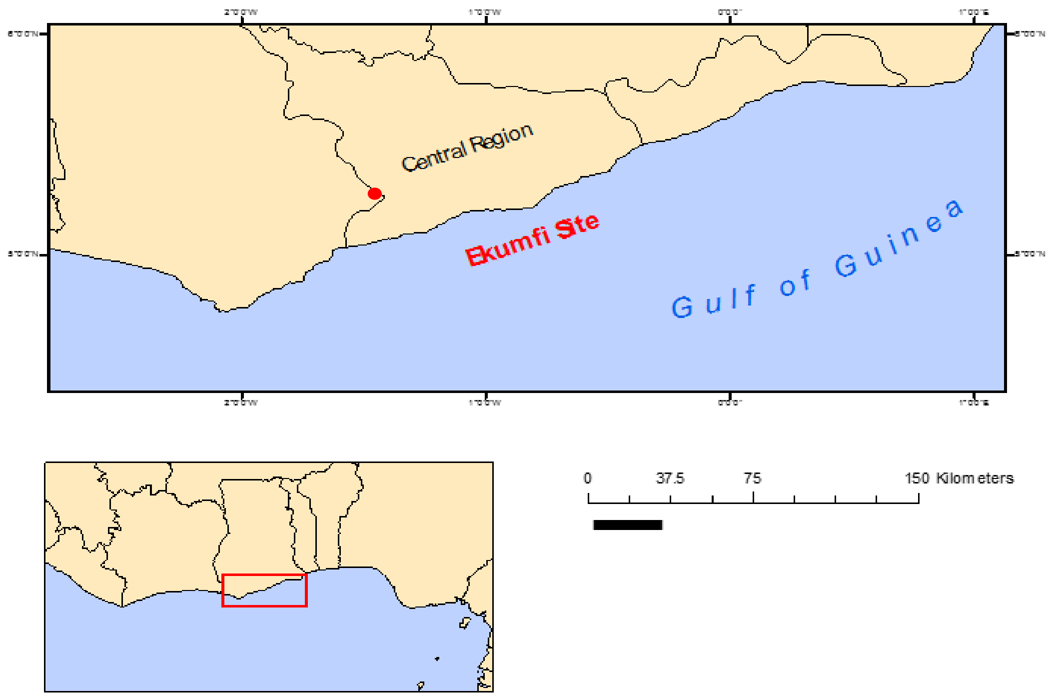


Figure 5-1 Map showing the location of the selected Ekumfi Site

[9] International Finance Corporation's Guidance Notes to Performance Standards on Environmental and Social Sustainability, January 2012.

Figure 5-2 Satellite imagery of the Proposed Ekumfi Site

The determination of the project's Area of Influence considers two basic concepts relating to area of direct impacts and area of indirect impacts.

AOI = Area of direct impacts + Area of indirect impacts

Area of direct impact would consider the physical footprints of the project such as right of way, construction sites, work staging area and areas affected during the operational phase.

Area of indirect impacts would include areas, which may experience induced or collative changes in combination with activities not under the direct control of the project. Usually this aspect is more difficult to define.

The area of influence therefore covers Aboano community, Kuntankure Settlement, Etsibeedu community, Otuam community within the Ekumfi District Assembly. ***Table 5-1*** and ***Figure 5-3*** show the distance between the project and nearest communities.

Table 5-1 Distance between the Project and the Nearest Communities

No.	Community	Direction	Distance
1	Ekumfi Aboano	West	420 m
2	Ekumfi Etsibeedu	North	500 m
3	Ekumfi Kontankore	East	560 m (Phase 1) 60m (Phase 2)
4	Ekumfi Otuam	East	1870 m (Phase 1) 1450 m (Phase 2)

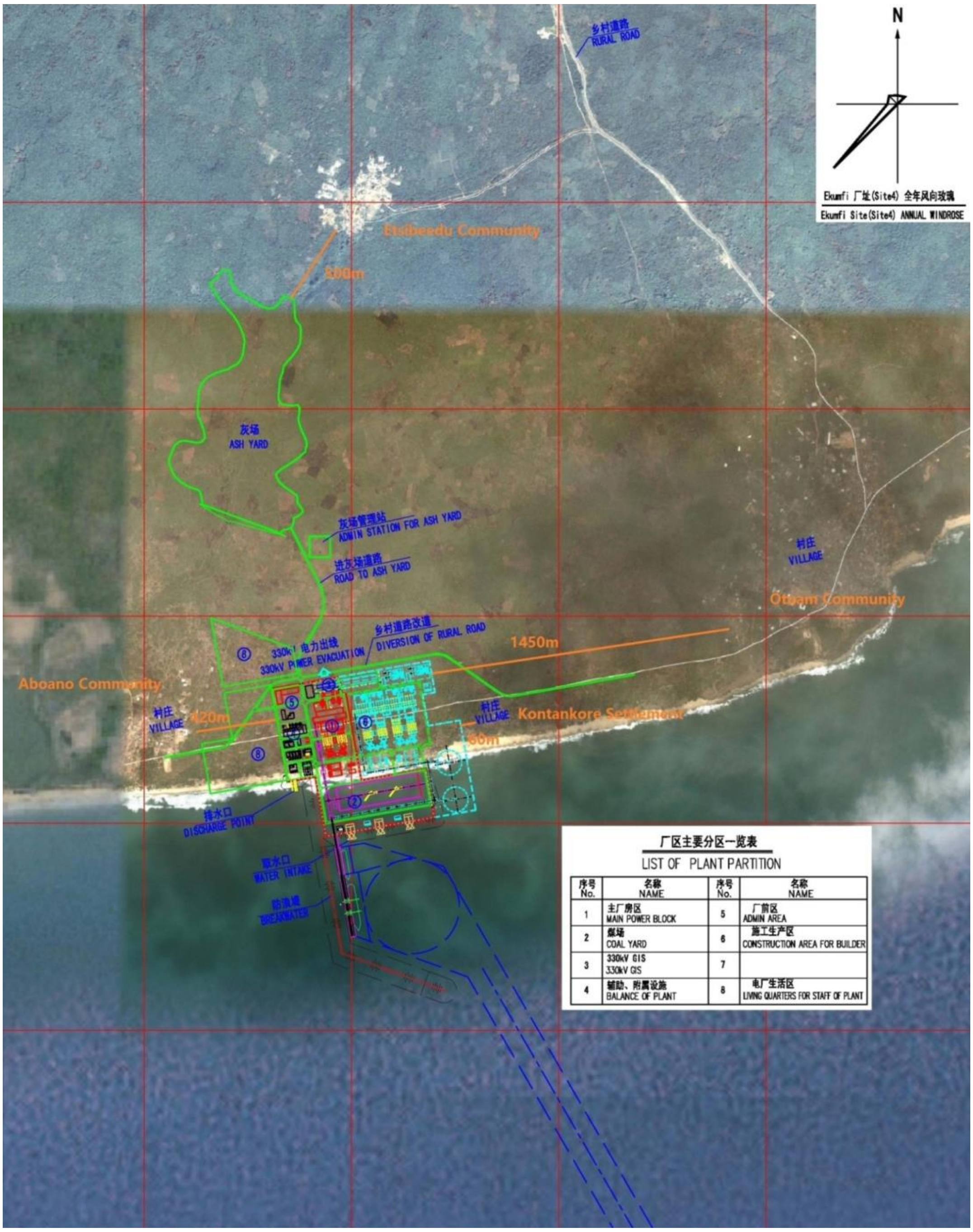


Figure 5-3 The Project and Nearest Communities

5.1 Climatic

The coast of Ghana belongs to the tropical climate zone, which has two main seasons: the rainy season and the dry season. The rainy season begins in April and lasts until September, and the dry season lasts from November to the next early April. Being close to the equator, Ghana has high temperature all the year round and the monthly averaged air temperature is 26^{0}C in the coastal region.

Months of February and March are relatively hot with highest air temperature rising up to 34^{0}C. The relatively cool months are August and September with the lowest air temperature recorded as 15^{0}C. The annual rainfall of Ghana is around 1200~1800mm for the south and southwest part, while for the northern is around 600~1200mm. The coastal areas of Ghana are dominated by the relatively stable southwest monsoon, for which the wind speed varies between 1.5~2.0m/s. While in the dry season the dry northeast wind occurs.

5.1.1 Temperature

According to the observation statistics from year 2010 to 2014, the monthly averaged air temperature ranged from 24.4 to 28.65. The highest temperature was 30.65 ^{0}C which occurred in April 2014 and the lowest temperature was 21.65^{0}C occurring in July 2012. The monthly average temperature statistics are listed in ***Table 5-2***.

Table 5-2 Monthly Mean Air Temperature Statistics (Unit: ^{0}C)

Year	**Month**											
	1	2	3	4	5	6	7	8	9	10	11	12
2010	26.81	27.99	28.16	28.65	28.6	27.5	25.97	25.48	25.78	26.87	27.07	27.29
2011	26.86	27.41	27.56	28.17	28.16	28.16	25.88	24.69	25.33	25.19	25.67	26.87
2012	27.2	26.64	27.34	27.76	27.75	26.82	25.47	24.5	25.12	26.15	26.91	27.9
2013	27.46	27.45	27.78	28.21	28.24	26.94	25.48	24.41	25.04	25.69	26.63	26.67
2014	27	26.74	26.9	27.99	28.26	28.4	26.05	24.77	25.19	25.82	26.67	26.85
Monthly highest	**29.05**	**28.75**	**29.95**	**30.65**	**30.05**	**30.25**	**28.65**	**24.75**	**25.65**	**27.85**	**29.5**	**28.65**
Monthly lowest	**22.75**	**23.65**	**24.65**	**24.75**	**26.65**	**25.95**	**23.34**	**21.75**	**22.85**	**25.35**	**24.75**	**23.34**

Source: Lake Environmental Resource Centre, Canada

5.1.2 Wind

The Monthly Mean Wind Speed statistics for the period 2010 to 2014 reveals that the highest monthly mean wind speed was 3.81m/s occurring in July 2010 and August 2014 and the lowest monthly mean wind speed was 2.46m/s occurring in November 2010. The wind speed statistics are provided as following in ***Table 5-3***.

Table 5-3 Monthly Mean Wind Speed Statistics (Unit: m/s)

Year	Month											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
2010	3.28	3.61	3.01	2.97	3.26	3.35	3.81	3.79	3.39	3.18	2.46	2.60
2011	2.60	3.28	3.32	3.19	3.17	3.59	3.49	3.79	3.77	3.31	2.69	2.71
2012	2.94	3.57	3.51	3.26	3.38	3.42	3.57	3.63	3.59	3.40	2.87	2.67
2013	2.94	3.29	3.37	3.06	3.03	3.46	3.61	3.68	3.73	3.43	2.87	2.97
2014	3.34	3.30	3.53	3.15	3.02	3.49	3.68	3.81	3.72	3.45	2.88	2.59

Source: Lake Environmental Resource Centre, Canada

Based on a special wind and wave study conducted by Hohai University of China(HHU) in November 2015 and reported in “Ghana 2x350MW Supercritical Coal-fired Power Plant Terminal-Numerical Wave Model Study”; the wind climate established from the CCMP and CFSR wind time series from year 1979 to 2014 at the power plant offshore location (Coordinate: 0.75°W, 4.5°N) are quoted as follows:

At this offshore location, the dominating wind direction is S~WSW with appearance frequency up to 90.3%, the most frequent wind direction is SW with appearance frequency up to 36.7%. WNW ~ ESE direction wind can hardly happen with appearance frequency only about 2.6%. The strong wind direction is SSW~WSW with annual average wind speed around 4.7 ~5.0m/s as well as annual maximum wind speed around 10.3~11.0m/s within this SSW~WSW direction. Appearance frequency of Beaufort wind scale 2 to scale 4 is up to 96.1%. Appearance frequency of wind speed larger than Beaufort wind scale 5 is around 1.21% and that happens within wind direction of S ~SSW. Appearance frequency of wind speed larger than Beaufort wind scale 6 is only 0.01%.

5.1.3 Rainfall

According to the observed rainfall statistics, the highest monthly average precipitation rate from 2010-2014 is 3.819mm/hr which occurred in July 2010 while the lowest monthly average precipitation rate was 0.001 which occurred in March 2013. The highest precipitation rate was recorded as 13.21mm/hr in August and a lowest precipitation rate was 0.25mm/hr recorded each month. Monthly precipitation statistics are presented below.

Table 5-4 Monthly Mean Rainfall Statistics (Unit: mm/hr)

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
2010	0.0085	0.019	0.010	0.055	0.149	0.366	3.819	0.184	0.359	0.172	0.107	0.057
2011	0.019	0.046	0.012	0.024	0.063	0.38	0.197	0.091	0.19	0.199	0.043	0.195
2012	0.114	0.031	0.003	0.060	0.095	0.528	0.201	0.103	0.226	0.102	0.155	0.223
2013	0.098	0.047	0.001	0.062	0.164	0.217	0.409	0.062	0.079	0.056	0.126	0.064
2014	0.025	0.007	0.005	0.035	0.128	0.332	0.374	0.583	0.199	0.086	0.278	0.048
Monthly Highest	**1.02**	**0.76**	**0.76**	**1.178**	**2.79**	**5.33**	**4.83**	**13.21**	**6.35**	**5.08**	**4.06**	**2.34**
Monthly Lowest		**0**	**0.25**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Source: Lake Environmental Resource Centre, Canada

5.1.4 Relative Humidity

According to the statistics, the highest relative humidity was recorded in November 2014 at 88.73% and the lowest was recorded as 80.69% which occurred in May, 2011. The average relative humidity statistics of each month are presented in ***Table 5-5***.

Table 5-5 Monthly Mean Relative Humidity (Unit: %)

Year	Month											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
2010	82.54	81.89	82.05	81.99	81.36	83.18	85.03	87.16	86.95	86.14	84.91	81.52
2011	82.21	84.08	83.21	81.03	80.69	82.72	85.80	87.51	88.14	86.76	85.34	82.97
2012	82.93	85.43	83.57	82.59	81.43	83.09	84.20	87.62	88.29	87.42	86.49	84.02
2013	81.47	82.97	83.18	82.29	81.53	82.60	84.98	87.40	87.36	87.53	86.43	82.06
2014	83.90	84.64	83.80	82.67	81.29	81.96	84.1	88.31	88.40	86.86	88.73	81.12

Source: Lake Environmental Resource Centre, Canada

5.1.5 Atmospheric Pressure

According to the observation statistics, 2014 recorded the highest surface pressure of 1011mb in July and the lowest of 1000 mb in the months of February, March, April and November. The monthly mean surface pressure is presented below in ***Table 5-6***.

Table 5-6 Monthly Mean Surface Pressure (Unit: mb)

Year	Month											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
2010	1004.2	1005	1005.3	1004.7	1005.9	1008	1008.3	1008.4	1007.1	1005.9	1004.6	1003.9
2011	1004	1004.6	1004.7	1004.6	1005.8	1007.5	1007.7	1008.5	1008.1	1005.5	1005.3	1005.3
2012	1005.3	1004.8	1005.3	1005.3	1006.7	1008.1	1008.3	1009.2	1008.6	1006.5	1005.2	1005.1
2013	1005.6	1004.8	1005.3	1005.6	1006.6	1007.9	1008.9	1008.6	1008.3	1007	1004.9	1008.7
2014	1005.5	1005.3	1005.4	1005.6	1005.9	1007.8	1009.7	1008.8	1008.2	1007.1	1005.9	1006
Monthly Highest	**1008**	**1008**	**1007**	**1006**	**1007**	**1009**	**1011**	**1009**	**1009**	**1008**	**1007**	**1006**
Monthly Lowest	**1002**	**1000**	**1000**	**1000**	**1002**	**1004**	**1004**	**1006**	**1002**	**1001**	**1000**	**999**

Source: Lake Environmental Resource Centre, Canada

5.2 Physical Environment

5.2.1 Geology

The geomorphy of the site shows degradation of the hills with varied slopes and scattered particularly within the plant area.

According to investigation in the site, no adverse geological actions exist such as landslip, mud-rock flow, goaf, land subsidence, etc. No alive fault is identified in the proposed project site and preliminarily it is considered that the proposed project site is located in comparatively stable area and is suitable for the construction and development of power plant.

Strata

The overburden within the site area is plain fill of Quaternary Holocene (Q_4^s), underneath which are granite of Proterozoic (Pt). The strata were listed below according to the field investigation, field test and laboratory test.

I. Quaternary Holocene artificial backfill (Q_4^s)

① Plain fill: brown, gray brown, many plant roots and humus in surface layer. The main component is fine sand, silty clay and silt. Some gravels were found partly, and this layer exists very commonly in the site. The thickness ranges of 0.80-2.90m, the bottom ranges of 0.80~2.90, and the bottom elevation ranges 9.84~26.03m.

II. Proterozoic (Pt)

Strong weathered granite: cinerous, gray, medium coarse grains formation, massive structure. The rock cores are mainly like coarse sand or gravels. The thickness ranges of 0.50-2.00m, the bottom ranges of 2.20~3.40, and the bottom elevation ranges 7.84~24.83m.

Medium weathered granite: cinerous, gray, medium coarse grains formation, massive structure. The rock cores are mainly columnar or long columnar. The largest thickness is 12.80m shown in this survey, and the actual thickness is not explored.

Determination of characteristic values of subsoil bearing capacity

According to engineering geological data of the project area, the characteristic values of stratum bearing capacity are preliminarily determined and listed in ***Table 5-7***.

Table 5-7 Characteristic Values of Subsoil Bearing Capacity

Stratum	f_{ak}（kPa）
Granite（strong weathered）	500～800
Granite（medium weathered）	1000～2500

In the excavating area, medium weathered granite can be taken as natural foundation bearing layers for such main buildings as main power house, turbine room, chimney and so on; strong or medium weathered granite can be taken as natural foundation bearing layers for other main buildings and large-loaded auxiliary buildings (structures).

In the backfilling area, natural foundation, replacement method or pile foundation can be taken for the foundation of buildings (structures) according to the foundation depth, backfilling depth, etc.

In general, the proposed project site has a relatively stable geologic features and therefore suitable for building a power plant.

5.2.2 Soil Quality (Chemical Parameter)

Soil samples were analyzed for pH and chemical elements, Poly Aromatic Hydrocarbons and Pesticides. The methods employed for the analysis was the colorimetric method using Palintest Soil Photometer probe sensor for pH following acceptable standard procedures.

Table 5-8 Chemical Parameter of Soil Quality

Chemical Analysis

Parameter	Unit	Value
pH		6.4
Sulfate	mg/kg	933.3
Chloride	mg/kg	42602.1
Phenol	mg/kg	30.67
Arsenic	mg/kg	2.33
Cadmium	µg/kg	68.21
Chromium	µg/kg	14.97
Copper	µg/kg	140.9
Lead	µg/kg	89.9
Mercury	µg/kg	6.05
Zinc	mg/kg	1.66
Total Petroleum Hydrocarbon	mg/kg	< 2
Benzene	ppb	< 0.1
Toluene	ppb	< 0.1
Ethyl-benzene	ppb	< 0.1
Xylene	ppb	< 0.1
Volatile Organic Compounds	ppm	0.14

Poly Aromatic Hydrocarbons (PAH)

Compound	Unit	Concentration
Naphthalene	µg/kg	< 0.001
Acenaphthylene	µg/kg	< 0.001
Acenaphthene	µg/kg	< 0.001
Fluorene	µg/kg	< 0.001
Phenanthrene	µg/kg	< 0.001
Anthracene	µg/kg	< 0.001
Fluoranthene	µg/kg	< 0.001
Pyrene	µg/kg	< 0.001
Benzo(a)anthracene	µg/kg	< 0.001
Chrysene	µg/kg	< 0.001
Benzo(b)fluoranthene	µg/kg	< 0.001
Benzo(j, k)fluoranthene	µg/kg	< 0.001
Benzo(a)pyrene	µg/kg	< 0.001
Ideno (123-cd)pyrene	µg/kg	< 0.001
Dibez(a, h)anthracene	µg/kg	< 0.001
Benzo(g,h,i)perylene	µg/kg	< 0.001

Pesticides

OCPs	Unit	Concentration
Beta- HCH	mg/kg	< 0.01
Gamma- HCH	mg/kg	< 0.01
Delta- HCH	mg/kg	< 0.01
Heptachlor	mg/kg	< 0.01
Aldrin	mg/kg	< 0.01

Gamma- Chlordane	mg/kg	< 0.01
Alpha- endosulfan	mg/kg	< 0.01
P, P´- DDD	mg/kg	< 0.01
P, P´- DDT	mg/kg	< 0.01
Endosulphan sulphate	mg/kg	< 0.01
Metoxychlor	mg/kg	< 0.01

PCBs	**Unit**	**Concentration**
PCB 28	mg/kg	< 0.01
PCB 52	mg/kg	< 0.01
PCB 101	mg/kg	< 0.01
PCB 153	mg/kg	< 0.01
PCB 138	mg/kg	< 0.01
PCB 118	mg/kg	< 0.01
PCB 180	mg/kg	< 0.01

5.2.3 Ground Water

The type of groundwater in the site is bedrock fissure water conserved in the bedrock fissure. The groundwater is mainly replenished by surface water from rainfall and its general run-off route is through evaporation.

No ground water was found within the depth of the soil investigation work. According to the site investigation and survey work, the average maximum water table is more than 20m.

A little perched water found in a low-lying area during the survey, which appears only in the wet season and disappears in the dry season. The water is conserved only in the soil strata 1~2m above the bedrock surface.

It is considered that the groundwater is corrosively weak to concrete, and strong to steel bar in reinforced concrete structures with alternating wet and dry situations.

5.2.4 Seismic Effect

According to “seismicity map of southern Ghana” Published by Ghana Geological Survey Department in 2004, there are no records about seismic activity in this site. Earthquake of magnitude over 4.1 has been recorded in Accra, which is 75 km to the northeast of the site. According to “Global Seismic Hazard Map” Published in 1990, The peak ground acceleration (PGA) is about 0.4~0.8 m/s^2 corresponding to a 475 years return period, 10% probability of exceedance in 50 years.

5.2.5 Hydrological Baseline

Site Hydrology

The proposed project site is located at Aboano in Ekumfi, which about 27km west of Winneba and 9km southwest of Mumford. The site is situated at the junction zone of hilly slope and Atlantic. The ground elevation is about -5 to 26m and a small gully runs through the site of this phase. There is a small gully on the north side of the planned site, the southeast corner of the planned site occupies the north-south gully on the east side. The vegetation around the site is dominated by low shrubs, dotted with palm, coconut trees and dense high grass. Part of this area has been cultivated for cropping.

Figure 5-4 Landform of the Proposed Project Area at Ekumfi

Flood Analysis of Ekumfi Site

The site is affected by small watershed flood, which can be divided into three small watersheds identified as northern side watershed, northeastern side watershed and eastern side water shed. The design peak flood flow at section of three watershed outlet, i.e. once-in-100-year design peak flood flow at northern side watershed is $4.73m^3/s$; once-in-100-year design peak flood flow at northeastern side watershed is $3.61m^3/s$; once-in-100-year design peak flood flow at eastern side watershed is $29.9m^3/s$.

Marine Hydrology

- Tide and Characteristic Tidal Level

The tide in sea area near the plant is semi-diurnal tide, the tidal epoch changes at intervals of about 6 hours. It appears two high tides and low tides in a lunar day and two consecutive high tides or low tides are not in the same height, the tide epoch and ebb tide time are unequal, and solar tide differs obviously.

Due to the lack of tide observation station in Ghana, all the data collected are just the tidal level forecast based on Takoradi Port for application and research. According to calculation, the high water level and low water level close to the site for different periods are as follows:

The high water level which may occur once in 100 years (P=1%）: 2.52m Extreme high water level (once-in-50-year): 2.50m and Extreme low water level (once-in-50-year): -0.45m

According to cumulative frequency statistics based on one-year high and low tide complete data of Tema Port in 2006, the design high water level with cumulative frequency of 10% of high tide and design low water level with cumulative frequency of 90% of low tide are given as: The design high water level: 1.58m and the design low water level: 0.36m.

- Waves

The coast of the Gulf of Guinea is largely open to south-westerly to south-south-easterly long swells induced by fetches in the South Atlantic Ocean. The coast around the study area is subjected to high wave intensity, dominated by swells with periods of 11-16 seconds which are superimposed on the near shore region on locally generated seas generally of a 3-8 seconds period.

Ash Yard Hydrology

The ash yard is located at about 800m north of plant site within the valley. The terrain is a narrow mountain valley leaning from northeast to southwest with a big gradient. The natural elevation of the ash yard is 10m to 26m. The ash yard of phase 1 covers about $63\times104m^2$. The ash yard is provided with the water drainage system including “vertical drain well+ drain ditch+ stilling pool”, in order to drain the rain water from the ash yard. Outside the ash yard the flood intercepting trench is built along the slope to lead the upstream flood to the low-lying place.

The ash yard is located in the concave valley surrounded by hills and highlands therefore the impact of the nearby river flood on site is not a necessary consideration.

Design Storm

According to the maximum daily rainfall data of the year 1976~2014 by Takoradi meteorological station, which is about 28km northeast of the plant site, P-III and Gumbel frequency methods are used to calculate the once-in-100-year, once-in-30-year and once-in-10-year maximum daily rainfall. Through comprehensive analysis, the calculation results by the method of P-III type are more reasonable. The once-in-100-year maximum daily rainfall is 182.4mm, the once-in-30-year maximum daily rainfall is 160.1mm, the once-in-10-year maximum daily rainfall is 136.7mm. According to the discontinuous maximum 24hrs rainfall data of the year 1980~2008 by Takoradi meteorological station, P-III and Gumbel frequency methods are used to calculate the once-in-100-year, once-in-30-year and once-in-10–year maximum 24hrs daily rainfall. Through comprehensive analysis, the calculation results by the method of P-III type are more reasonable.

The once-in-100-year maximum 24 hours' rainfall is 210.6mm, the once-in-30-year maximum 24 hours' rainfall is 184.5mm, the once-in-10-year maximum 24 hours' rainfall is 157.4mm. The yearly maximum 24 hours' rainfall during 1980~2008 is not complete and the time span is short therefore the results would not be good representation.

According to the regulations, ratio 1:2 is used to modify the maximum daily rainfall, whose results are no different from the results by the direct calculation of the maximum 24hrs rainfall. Therefore, the modified maximum 24hrs rainfall is used for the design storm.

5.2.6 Ambient Air Quality

The results of the 16-days background ambient air quality monitoring carried out from 5-21 January 2016 for the Harmattan (Dry) season is presented in ***Table 5-9A*** and from 1-16 August for the Wet season is presented in ***Table 5-10B.*** The reported concentrations were largely lower than the Ghana EPA ambient air quality guidelines but with TSP and PM consuming the guideline by 26.19% and 76.06% respectively due possibly to the severe harmattan at the time of the measurements.

Table 5-9A Background Ambient Air Quality Concentrations at Proposed Ekumfi Site (Unit: ug/m³) – Harmattan Season

Date	**CO (µg/m3)**	**NO2 (µg/m3)**	**SO2 (µg/m3)**	**TSP (µg/m3)**	**PM10 (µg/m3)**
5-Jan-16	559.33	0.17	32.73	105.89	96.02
6-Jan-16	563.49	5.65	51.74	123.79	108.34
7-Jan-16	556.19	32.02	63.82	79.66	65.24
8-Jan-16	567.06	10.23	53.56	57.65	51.34
9-Jan-16	569.13	6.12	94.03	65.21	56.65
10-Jan-16	574.33	1.03	68.88	63.78	57.16
11-Jan-16	572.21	0.83	68.41	52.66	46.54
12-Jan-16	571.72	0.09	60.64	44.75	40.23
13-Jan-16	709.16	0.14	54.60	43.98	39.69
14-Jan-16	887.29	1.50	76.24	42.55	36.44
15-Jan-16	984.88	0.78	61.02	45.25	39.42
16-Jan-16	923.17	4.32	82.23	48.29	44.09
17-Jan-16	779.06	1.20	59.18	50.77	45.69
18-Jan-16	752.33	0.71	64.12	53.13	46.35
19-Jan-16	868.89	0.74	43.78	49.30	44.93
20-Jan-16	990.70	1.45	59.40	37.04	33.67
Average	**714.31**	**4.19**	**62.15**	**60.23**	**53.24**
EPA Guideline	10000.00	150.00	150.00	230.00	70.00

Note: Monitoring was done with time-integrated AQM60 Station.

Table 5-10B Background Ambient Air Quality Concentrations at Proposed Ekumfi Site (Unit: ug/m³) – Wet Season

Date	CO (µg/m3)	NO2 (µg/m3)	SO2 (µg/m3)	TSP (µg/m3)	PM10 (µg/m3)
1-Aug-16	233.92	5.25	17.04	32.44	29.46
2- Aug -16	229.04	1.61	22.01	25.57	23.33
3- Aug -16	233.20	4.24	25.19	31.05	28.38
4- Aug -16	237.43	7.31	27.16	25.77	23.48
5- Aug -16	242.97	5.10	26.22	18.43	16.76
6- Aug -16	248.52	5.55	34.33	16.22	14.69
7- Aug -16	239.39	6.37	39.40	25.08	22.91
8- Aug -16	245.67	6.99	38.36	38.67	35.36
9- Aug -16	253.59	9.58	41.60	36.41	33.19
10- Aug -16	247.16	16.60	43.20	28.47	25.95
11-Aug -16	258.23	12.86	37.20	23.20	21.03
12- Aug -16	255.69	20.02	43.56	25.83	23.44
13- Aug -16	257.99	22.40	45.78	14.59	13.15
14- Aug -16	260.74	19.45	43.58	18.83	17.11
15- Aug -16	251.30	38.68	54.99	20.75	18.71
16- Aug -16	273.63	33.98	46.00	14.68	13.21
Average	**248.03**	**13.50**	**36.60**	**24.75**	**22.51**
EPA Guideline	10000.00	150.00	150.00	230.00	70.00

Note: Monitoring was done with time-integrated AQM60 Station.

5.2.7 Ambient Noise

The result of 16 days on-site monitoring of background noise from 5-21 January 2016 and subsequent 24-hour monitoring of other locations including Aboano Community, Etsibeedu Community, Otuam Community and Pillar G1 on the concession.

Table 5-11 Background Ambient Noise at Proposed Ekumfi Site

No	Location	Leq dBA
1	Concession (G1)	59.41
2	Boundary of Concession	55.71
3	Aboano Community	65.54
4	Otuam Community	61.93
5	Estibaadu Community	63.91

In general, the noise levels were considerably high and above the EPA guideline standards especially within the community settlement.

5.3 Biological Environment

5.3.1 Terrestrial Ecological Baseline

Flora

The proposed project site lies in Maritime and the Coastal Scrub and Grassland vegetation zones (Taylor, 1960). The zone has been extensively farmed and as a result has become highly degraded. Part of the area coincides with the Southern Marginal forest type (Hall and Swaine 1981). Remnants of the original vegetation of the area are found in isolated pockets as forest reserves or sacred grove. Some of the prominent species of this vegetation type are *Dichrostachys cinerea, Zanthoxylum xanthoxyloides, Carissa edulis, waltheria indica, Elaeophorbia drupifera, Heteropogon contortus, Vetiveria sp., Ctenium spp., Andropogon spp.* and *Heteropogon contortus.*

The Maritime vegetation comprises Strand and Mangrove vegetation types. The Strand vegetation occupies the foreshore, above the high-water mark and typically has species such as *Canavalia rosea, Ipomoea pes-caprae* and *Cyperus maritimus.* Coconut plantations occur on the sand bar. The mangrove vegetation occurs in brackish water which is subject to tidal influences – along the seaward side of lagoons and in the tidal parts of creeks and rivers. Some of the Characteristic species are *Avicennia germinans, Laguncularia racemosa* and *Rhizophora sp.*

The project site has three types of vegetation namely (i) Maritime, (ii) Thicket and (iii) Farms and farm re-growth.

The Maritime Vegetation consists of the poorly developed and highly disturbed Coastal Strand and a small patch of mangrove vegetations. The Strand here is very patchy and has species such as *Ipomoea pes-caprae, Cyperus maritimus, Canavalia rosea, Sansevieria liberica* and *Opuntia vulgaris*.

Portions of the Strand have been converted into coconut plantation and settlements. The patch of mangrove occurs along the seasonal Kontankore stream and has species such as *Avicennia germinans, Conocarpus erectus* and *Thespesia populnea.*


Plate 1a: Strand with coconut and settlement


Plate 1b: Patchy Strand vegetation


Plate 2a and 2b: Small patch of mangrove at estuary of small seasonal stream (Kuntakure)

Thicket Vegetation **-** Well-drained, relatively undisturbed areas of the project site are occupied by scrub or thicket vegetation – a dense tangle of small trees, shrubs and climbers. The dominant tree species here is the introduced *Azadirachta indica* (neem tree) that is harvested as fuel wood (Plate 3a). Fire had damaged large sections of the thicket vegetation on the project site (Plate 3b).

a 

b 
Plate 3: Thicket vegetation (a) intact thicket (b) burnt thicket

Farms and Farm Re-growth vegetation **-** Outside the natural areas described above, farms, fallows and grassland occupy large sections of the study area. The crops grown are mainly Groundnuts (*Arachis hypogea*) Tigernuts (*Cyperus esculentus*) and Cassava (*Manihot esculenta*). Grasses, mainly guinea grass (*Panicum maximum*) and *Imperata cylindrica* (lalang), and non-forest weeds (*Synedrella nodiflora*, *Sida acuta* and *Amaranthus spinosus*) dominate the farm re-growths. Grassland vegetation occurs on the poorly drained and impoverished soils of the study area. The dominant grasses are *Panicum maximum*, *Imperata cylindrica*, *Heteropogon contortus* and *Andropogon* sp.

a  b 

Plate 4(a) foreground shows remnants of Tiger nuts; (b) burnt farm remnants

A total of 67 species belonging to 36 families and 60 genera were identified within the proposed project area. The family represented by the greatest number of species was Gramineae. This was followed by Papilionaceae and Euphorbiaceae with 6 species and 7 species respectively. All other families recorded were represented by less than 5 species.

The life form composition of the species is represented as following:

Table 5-12 Life Form Composition of Species

Life Form	Frequency	%
Tree	22	32.84
Herb	13	19.40
Climber	12	17.91
Shrub	20	29.85
Total	67	100.00

Generally, the flora baseline shows that the vegetation of the project site has been largely modified by human activities. Fishing, farming and settlement developments as well as bush burning were identified as the major drivers of vegetation degradation within the proposed project site. The small patch of mangrove at the mouth of the Kontankure stream should be expanded and preserved.

The species of conservation concern identified include *Ritchea reflexa* (Gold Star), *Uvaria chamae* and *Sansevieria liberica* occuring in a vegetation zone that is decreasing in size because of human impacts. It is recommended that natural areas with these species be maintained in buffer zones of the project site.

Fauna

Generally, the wildlife of Southern Ghana and in the Central Region is very rich and diverse. Thirty-nine (39) mammal species have been documented (Wildlife Division of Forestry Commission, 2010) out of which six (6) are of conservation Importance internationally; 1 listed as Endangered, 1 Near Threatened and 4 Vulnerable on the IUCN list of Threatened Species. Of the 243 bird species documented in the Region, 10 are of conservation importance on the IUCN Red List of Threatened species (Ghana Wildlife Society, 2006). However, none of the documented fauna of international conservation importance were recorded in the area during the current baseline survey.

Investigations had revealed that the abundance and diversity of wildlife species in the area has reduced drastically over the past two decade. The relatively few species still occuring in the project area are notably mammal species identified to include duikers (*Cephalophus* spp), Bushbuck (*Tragelaphus scriptus*), Royal Antelope (*Neotragus pygmaeus*) and African Civet (*Viverra civetta*). None of the mammal species mentioned were of conservation importance on the IUCN Red List of Threatened Species and the Ghana Wildlife Conservation Regulations.

The Hooded vulture (*Necrosyrtes monachus*) is among the avifauna identified in the area and is listed as Endangered on the IUCN Red List of Threatened Species. The cattle egret (*Bubulcus ibis*), Pied Crow (*Corus albus*), and the Black kite (*Milvus migrans*) are Completely Protected by the Wildlife Conservation Regulations of Ghana. Four reptiles reported to occur in the general area were of conservation importance; the Dwarf crocodile (*Osteolaemus tetraspis*) and Home's hinged tortoise (*Kinixys homeana*) are mentioned as Vulnerable by IUCN while the Nile monitor (*Varanus niloticus ornatus*) and Nile crocodile (*Crocodylus niloticus*) are Completely Protected by the Ghana Wildlife Conservation Regulations.

Five species of mammals belonging to four families were identified. Generally, the diversity and abundance of the species within the project area were very low. The Ground Squirrel (*Spermophilus adocetus)* is the dominant fauna noted. All the species identified are categorized as Least Concern on the IUCN Red List of Threatened Species, however they are Partly Protected under the Wildlife Conservation Regulations of Ghana

All the mammal species identified are recognized close season protected, under the Wildlife Conservation Regulation 1971, LI 685. Hunting or capturing of all wildlife species, including those that are partly protected, is prohibited between the months of August 1st to December 1st.

Table 5-13 Species of Mammals Recorded in the Project Areas during Field Surveys and their Conservation Importance

SPECIES				CONSERVATION STATUS				
ENGLISH NAME	SCIENTIFIC NAMES	FAMILY	ORDER	IUCN				
				EN	VU	NT	LC	WCR
Bushbuck	Tragelaphus scriptus	Bovidae	Artiodactyla				+	PP
Duiker	Cephalophinae sp.	Bovidae	Artiodactyla				+	PP
Gambian Giant rat	Cricetomys gambianus	Nesomyidae	Rodentia				+	PP
Grasscutter	Thryonomys swinderianus	Thryonomyidae	Rodentia				+	PP
Ground squirrel	Spermophilus adocetus	Sciuridae	Rodentia				+	PP

(*LC- Least Concern; NT- Near Threatened; VU- Vulnerable; EN- Endangered; WCR- Wildlife Conservation Regulation; PP- Partly Protected; Empty cell- Data Deficient)*

Avifauna

Bird population and species diversity within the project site are very low. A total of 25 bird species were identified during the survey of which the Village weaver (*Ploceus cucullatus*) was the most dominant followed by Black kite (*Milvus migrans*) and Black and White Mannikn (*Lonchura bicolor*). Of the 25 species of birds recorded, 24 are designated as Least Concern on the IUCN Red List of endangered species. None of the species were Endangered, Near Threatened or Vulnerable. However, the Endangered hooded vulture (*Necrosyrtes monachus*), was reported to occur in the area. Twenty-one of the species recorded are Partly Protected with 4 being completely protected by the Wildlife Conservation Regulation of Ghana.

Table 5-14 Species of Birds Recorded in the Project Areas during Field Surveys and their Conservation Importance

SPECIES		CONSERVATION STATUS					
ENGLISH NAME	SCIENTIFIC NAMES	IUCN				WCR	
		EN	VU	NT	LC	CP	PP
Afican pied wagtail	Motacilla aguimp				+		+
African Grey Hornbill	Tockus nasutus				+		+
Black and White Mannikin	Lonchura bicolor				+		+
Black Kite	Milvus migrans				+	+	
Bronze Mannikin	Lonchura cucullata				+		+
Buff throated Sunbird	Nectarinia adelberti				+		+
Cattle egret	Bubulcus ibis				+	+	
Common Bulbul	Pycnonotus barbatus				+		+
Double Spurred francolin	Pternistis bicalcaratus				+		+
Gabon Woodpecker	Dendropicos gabonensis				+		+
Green headed Sunbird	Cyanomitra verticalis				+		+
Grey Backed Camaroptera	Camaroptera brevicaudata						+
Grey headed sparrow	Passer griseus				+		+
Grey Kestrel	Falco ardosiaceus				+	+	
Laughing Dove	Streptopelia senegalensis				+		+
Pied Crow	Corvus albus				+	+	
Plain Nightjar	Caprimulgus inornatus				+		+
Purple Glossy Starling	Lamprotornis purpureus				+		+
Splendid Glossy	Lamprotornis				+		+

Starling	splendidus						
Splendid Sunbird	*Nectarinia coccinigaster*				+		+
Standard winged nightjar	Caprimulgus longipennis				+		+
Western Grey Plantain-eater	Crinifer piscator				+		+
White throated bee-eater	Merops albicollis				+		+
Willage weaver	Ploceus cucullatus				+		+
Yellow Crowned Gonolek	Laniarius barbarus				+		+

(*LC- Least Concern; NT- Near Threatened; VU- Vulnerable; EN- Endangered; WCR- Wildlife Conservation Regulation; PP- Partly Protected; CP- Completely Protected; Empty cell- Data Deficient;)*

Reptiles and Amphibians

Only one reptile species (*Agama agama*) was recorded within the project area during the surveys. The calls of several amphibians (frogs) were heard from water ponds within the project area during night surveys.

Snake species have been reported to occur in project area and the buffer. Most of the snakes including large species such as the African python (*Python sebae*) and Royal python (*Python regia*) reported to inhabit the area, are seldom encountered by the locals.

Table 5-15 Species of Reptiles and Amphibians Recorded in the Project Areas during Field Surveys and their Conservation Importance

COMMON NAME	SCIENTIFIC NAME	CONSERVATION STATUS					
		IUCN				WCR	
REPTILES		EN	VU	NT	LC	CP	PP
	Squamata: Lacertilia						
Agama lizard	Agama agama				+		

(*LC- Least Concern; NT- Near Threatened; VU- Vulnerable; EN- Endangered; WCR- Wildlife Conservation Regulation; PP- Partly Protected; CP- Completely Protected; Empty cell- Data Deficient)*

In general, coastal development has been reported to have negative impact on wildlife through direct displacement, mortality, reduced reproductive rates, and increased susceptibility for predator capture. Evidently, the diversity and population of wildlife species within the project area was very low. The highly burnt nature of the project area was a contributing factor to the few wildlife species encountered. Bushfire had cleared majority of the project area resulting in the absence of vegetation at most parts of the area.

The project site is characterized by the occurrence of extremely low abundance and diversity of fauna resulting from the few habitat types available in the project area. The situation therefore greatly reduces the sensitivity of the project site and the related impacts that the project is likely to have on mammals. The proposed project is therefore anticipated to have a trifling impact on wildlife and their habitat in the area.

However, it is anticipated that amphibians (frogs) are likely to lose their habitat, breeding space and fauna mortality during the construction phase. Nonetheless, these frogs are however temporal inhabitants and moves away when the ponds dry especially during the drier season of the year.

Most of the species present in the area occasionally drink water from the ponds and streams in the area, especially during the dry season.

Fauna (birds and mammals) that utilize the water ponds for drinking and feeding will also lose their feeding habitats. But this will not be significant loss since not many birds we recorded to utilise the project site for feeding habitat.

The field survey showed that no breeding habitat for any species of mammal or bird will be impacted by the project. The absence of breeding signs for these fauna in the project site is indicative that the area is not utilised for breeding by these wildlife species.

Most Wildlife in Ghana is reported to breed between the month of August and December. A wet season survey is required to ascertain whether or not the wildlife breed in the area especially those burrowing ones' whole give birth and keep their young in holes.

Generally, the proposed project area has experienced significant change in the ecological condition of the habitat and the associated species over the years. Threats to wildlife and their habitat in the area include habitat degradation, habitat conversion (for settlements, farming) and hunting. Disturbance from these human activities were sources of threat to wildlife in the area.

The low numbers of fauna in the area is a significant findings made during the survey. Most of the mammals, birds and reptiles documented to previously occur in the survey area were not encountered during the recent survey because they are no more using the area or the population has declined greatly that sighting has become very difficult. The numerous disturbances within the project area such as frequent bushfires degrade pristine habitats which could have resulted in the decline of wildlife.

5.3.2 Offshore and Marine Ecological Baseline

Fishes

A coastal fishery survey was conducted as part of the ESIA to describe the fishing activities at Ekumfi Aboano and identify the different fish species caught; in order to understand the diversity and stock seasonality of fish of the marine environment fringing the project area. The beach seine is the only fishing gear used by fishermen at the area. The result of the fishery survey in the area is shown in ***Table 5-16***.

The methodology adopted for the survey involved sample collection, interview and observation and review of secondary data. Fish samples for the study were obtained from the beach seine landing site at Kontankure (coordinates: N 5° 12' 40.28", W 0° 49' 44.07") near the project area. The beach seine mainly targets pelagic and near shore demersal species.

Table 5-16 Fish Species Found in the Area

Family	Species	Common Name
Acanthuridae	Acanthurusmonroviae	Monrovia doctorfish, surgeon fish
Balistidae	Balistespunctatus	Grey triggerfish
	Canthidermismaculatus	Rough triggerfish
Bathidae	Scyaciummicrurum	Rock sole, flounder
Bothidae	Syaciummicrurum	Channel flounder
Carangidae	Alectisalexandrinus	Alexandria pompano
	Caranx hippos	Crevalle jack
	Caranxcrysos	Blue runner
	Chloroscombruschrysurus	Atlantic bumper

Family	Species	Common Name
	Decapteruspunctatus	Round scad
	Decapterus rhonchus	False scad
	Lichiaamia	Leer fish
	Selene dorsalis	African moonfish, African lookdown
	Trachinotusteraia	Terai pompano
Clupeidae	IllishaAfricana	Long-finnned herring, West African Illisha
	Ethmalosadorsalis	Shad, Bonga
	Sardinellamaderensis	Flat sardinella
	Sardinellaaurita	Round sardinella
Cynoglossidae	Cynoglossussenegalensis	Senegal left eyed tongue sole
Dasyatidae	Dasyatis margarita	Daisy sting ray
Drepanidae	Drepane Africana	African sicklefish
Lutjanidae	Lutjanusagennes	African red snapper
Mullidae	Pseudupenusprayensis	West African goatfish
Palinuridae	Panulirusregius	Royal spiny lobster
Penaeidae	Penaeusnotialis	Pink shrimp
Pomadaysidae	Brachydeuterusauritus	Burrito, Bigeye grunt
	Pomadasysjubelini	Spotted burrito
Polynemidae	Galeoidesdecadactylus	Lesser African threadfin
Portunidae	Callinectesamnicola	Blue swimming crab
Rajidae	Raja miraletus	Brown ray
Rhinobatidae	Rhinobatosalbomaculatus	White-spotted guitarfish
Rinobatidae	Rhinobatusrhinobatus	Common guitarfish
Sciaenidae	Pseudotolithussenegalensis	Cassava croaker
	Pseudotolithusbrachygnathus	law croaker

Family	Species	Common Name
	Pseudotolithustypus	Long neck croaker
	Pteroscionpeli	Boe drum
Scombridae	Sardasarda	Atlantic bonito
	Orcynopsis unicolor	Plain bonito
	Scomberomorustritor	Spanish mackerel fish
Sepiidae	Sepia officinalis	Common cuttlefish
Sparidae	Pagellusbellottii	Red Pandora
Sphyraenidae	Sphyraenasphyraena	Barracuda
Stromateidae	Stromateusfiatola	Butterfish
Tetraodontidae	Lagocephaluslaevigatus	smooth puffer
	Ephippionguttifer	Prickly puffer
Trichiuridae	Trichiuruslepturus	Ribbonfish
	Alectis alexandrines	Alexandria pompano
	Balistespunctatus	Grey triggerfish
	Callinectesamnicola	Blue smimmingcrab
	Pagellusbellottii	Red Pandora
	Caranx hippos	Crevalle jack
	Lutjanusagennes	African red snapper

Extensive study of beach seine catches of the central coastline of Ghana, including the study area shows that the species: *Chloroscombruschrysurus*, *Brachydeuterusauritus*, *Ilishaafricana*, *Sardinellaaurita* and *Selenedorsalis*are among the dominant species landed at the beaches whilst *Acanthurusmonroviae, Penaeusnotialis, Galeoidesdecadactylus* and *Trichiuruslepturus* are in low abundance (Aggrey-Fynn & Sackey-Mensah, 2012).

5.3.3 Marine Turtle

Marine turtles play important roles in the marine ecosystem, as well as the terrestrial environment. They are used in diverse ways as dietary, medical, cultural, economic, and religious human need and wants (Laqueux, 1998; Robinson and Redford, 1991; Freese, 1997). Turtles consume diverse forms of prey, including jellyfish, crustaceans, sponges, tunicates, sea grasses, and algae. Most species of turtle increase fish stocks through feeding on jelly fishes which, when in large numbers, are considered a threat to fisheries (Mckeown*et al.*, 2003). In the sea, juvenile turtles are eaten by predators such as crabs and sharks. The extinction of various sea turtle species would thus mean a reduction in the abundance and diversity of such life. Sea turtles have been found to promote the growth and development of reefs and sea grasses. By coming ashore to nest, sea turtles transport nutrients from highly productive marine habitats such as sea-grass beds to energy-poor habitats like sandy beaches (Bouchard and Bjorndal, 2000). This helps reverse the usual flow of nutrients from land to sea and enhance vegetation growth at the beach which help stabilize the beach by reducing erosion.

In the Central region of Ghana, nesting activities of sea turtles has been reported for Green (*Cheloniamydas*), Olive ridley (*Lepidochelysolivacea*), and the Leatherback (*Dermochelysimbricata*) as the three main species that nest in along the sandy beaches (Agyekumhene et al., 2014). The olive ridley and leatherback appear to nest most frequently and in appreciable quantities along the central coasts of Ghana (Allman and Armah, 2008). The green sporadically nest in the area but are also occasionally encountered at sea by fishermen when they get entangled in nets during fishing operations. The Olive ridley is known to show the highest relative abundance in in the Central Region of Ghana (Agyekumhene et al., 2014).

The primary threats to the survival of sea turtle populations in the Central regions are mostly anthropogenic (Agyekumhene et al., 2014). Sea turtles and their eggs are routinely harvested when deposited in proximity to fishing communities. The eggs of sea turtle are also destroyed by predation from animals such as dogs and pigs, inundation from high tides, and erosion of sandy beaches. Adult turtles are also often accidentally captured in artisanal fisheries which cause them to drown and die. These animals are typically adults that may be breeding and feeding in the area. Protecting these adults is thus paramount to increasing the population, size and recovery of the species (Mazaris*et al.* 2005).

Habitat destruction through pollution, coastal development, artificial illumination on nesting beaches, accumulation of debris on the beach and changes in beach morphology that can prevent the female turtle from ascending the nesting beaches, are among identified threats to sea turtles in the Central Regions (Wildlife Division-Winneba, *unpublished*).

The rate of beach erosion and morphological changes is increased by community members who mine sand along the beaches. Poaching of sea turtle is very common in most coastal communities of the Central regions. Nesting females are usually collected for food and therefore for sale. The low fish catch coupled with low income levels in most of these communities have increased the incidence of sea turtle poaching. There are no traditional regulations, myths or by-laws in the Central Region that offer sea turtles protection.

Unfortunately, there is no documented sea turtle data or information on sea turtle activities or threats specifically existing for the project area.

Sea Turtle Nesting Activities in the Project Area

Factors such as beach elevation or accessibility of beach, beach height, type of sediment or substrate type (muddy or sandy), and grain size of sand, compressibility of sand and thermal variations in the sandy beach have been found to influence the choice of beach for nesting by sea turtles (Stoneburner and Richardson, 1981).

Most of the beaches within the footprint of the project are rocky with high cliffs which may prevent sea turtle from nesting or accessing the back beach. The rocky intersection of the beaches in the project area is too high for any turtle to access even at the highest tide of the day. Also the soil type at the back beach in the project area is too compacted (from human activities) for any successful digging of egg chamber to occur. Major parts of the beaches within the immediate impact zones of the project are therefore unlikely to support significant sea turtle nesting. However, the beach outside the project area to the east and west have gentle slope and could therefore support successful nesting at the back beach.

Different turtles prefer different types of beaches for nesting. For example, olive ridleys and leatherbacks most often prefer open areas, wide beaches with steep slopes and sand bars at river mouths, while hawksbill turtles prefer small island beaches and often nest under overhanging vegetation (Shanker*et al.*, 2003a; 2003b). The beach type preference of green turtles also ranges from large, open to small cove beaches (Shanker*et al.,* 2003a; 2003b). The project area has very dynamic beaches which are preferred by leatherback for nesting. However, the numerous segments at high ranging rocky shore areas of the project site reduce the suitability of the area for nesting by leatherbacks. The absence of leatherbacks nesting activities in recent times as reported in the area by local fishermen could be due to this factor.

The only section of the beach that has a wider back beach to favour olive ridley nesting was around the areas outside of the project impact zones. But the presence of intense disturbance from activities of the coastal communities such as light from homes, fishing, docking of canoes and boats on the beach etc disturbs the sandy beach and reduces the suitability of these areas for olive ridley nesting. Several boats on the beach reduce the area available for turtle to nest.

Three olive ridley shells were encountered during the two-day survey. The observations are indicative of the presence of the species in the area as reported by the local fishermen interviewed.

Sea turtles in the area face many and diverse threats both in the waters and on the nesting beach resulting in their low numbers. In the project area, nesting females are in danger of being harvested on the beach for food and income or captured in fishing gear. Turtle nests deposited on the sandy beach in the project area is susceptible to erosion or inundation by the high tides due to the narrow nature of the beach. Nests are also in danger of predation by pigs and dogs. Artificial lighting on the beach can also disorient nesting females and hatchlings but to a minimal extent.

The detailed study methodology and description of the baseline are provided in the ***Independent Report 1: Ecological Survey and Habitat Assessment Study***.

5.4 Landscape and Seascape

The landscape and seascape visual characteristics generally reflect natural but exploited environment resulting from human activities.

5.4.1 Landscape Character

The site is located along the coastal beaches of Ekumfi, which also coincides with the Southern Marginal Forest in the Central Region. Generally, the site depicts maritime and coastal scrub and grassland vegetation with hilly and rocky outcrops and isolated pockets of natural thickets of forest reserves or sacred groves.

The project site, in particular, demonstrates plant outgrowth on rocky surface and lying along the coastline (See ***Figure 5-5***).

Figure 5-5 Landscape Characteristics

There can be a visualization of a distinct relationship between the shoreline with its different spectral colours and shades and pockets of mangrove, weeds and ground cover including thickets of coconut trees which can be subdued by an overwhelming shade of skycap. These impressions of landscape often characterize casual visits to the site. However, same is likely to be lost due to the development of the proposed coal handling terminal. The potential visual impact can therefore be described as significantly adverse on the inhabitants.

The envisaged development would result in the construction massive structures and infrastructure, which would significantly alter the landscape along the immediate coastline and causing considerable change of the natural environment.

5.4.2 Landscape Visual Aspect

Presently, the topography is hilly with sparse vegetation and scattered pockets of thickets, which represent the general surrounding environment and though disturbed appears very natural landscape.

5.4.3 Seascape Character

Presently, the seascape is represented by coastline with maritime vegetation intersperse with strand and mangrove vegetation occupying the foreshore. The shoreline also portrays high water mark with outcropped rocky beach stretching almost the length of the site.

Although the ground is largely evenly laid and flat, it will lose this quality because the existing rocks, which would be removed for use as the main material for the construction of the Breakwater embankment.

At the moment, erosion is not a major concern along the shoreline. Again, the blasting and removal of the rocks is likely to result in some amount of erosion which must be checked immediately. The engineering considers cutting and filling, which would remove the rocks.

5.4.4 Seascape Visual

The sea line depicts identifiable straight line that can easily be placed in the subconscious. This identity would likely be lost and completely replaced with the development of the breakwater embankment and quays connecting the plant site and the port terminal.

The overall aesthetic quality therefore depicts natural environment which given the village setting has friendly and positive impact on the people. The vegetation continues to change through the seasonal variations also influences the visual impressions and consequent impact implications.

It can therefore be concluded that presently, the baseline visual aspects of the landscape and seascape are considerably friendly and hardly have adverse impact implications on the people.

The detailed study methodology and description of the baseline are provided in the ***Independent Report 3: Landscape, Seascape and Visual Impact Assessment***.

5.5 Social and Economic Baseline

5.5.1 Administrative Structure

Ekumfi Srafa Aboano falls within the jurisdiction of the Ekumfi District Assembly, which is made up of thirty-seven (37) Assembly Members, the District Chief Executive (DCE) and a Presiding Member. The DCE is appointed by the President of Ghana with support from two-thirds of the Assembly Members. Twenty-six (26) of the 37 Assembly members are elected members and 11 are government appointees. The District has one constituency (the Ekumfi Constituency) and eight area councils namely Essarkyir, Ebiram, Ekrawfo, Otuam, Narkwa, Eyisam, Srafa (Abono) and Asaafa (Ghana Statistical Service, 2014).

The traditional capital of Ekumfi Traditional Area Council is at Ebiram where the paramount chief of the council rules from. He is supported by a number of divisional chiefs (Ghana Statistical Service, 2014). The people of Aboano are headed by a Chief who is supported by a Queenmother and elders in administering the community. All issues especially relating to land acquisition is dealt with by the Chief/elders and the respective land owners.

5.5.2 Demographics

There are approximately 52,000 people inhabiting the Ekumfi District out of which 1900 of the District's population reside in Ekumfi Aboano (GSS, 2014). The population of E. Aboano is considered youthful because approximately 55.9 % of the population is children.

In the District, females make up the greater percentage (53.8 %) with a sex ratio of 85.7 males to 100 females. This ratio is high at ages 14 years and below (103.7) and rather low in the population of age 65 years and above (49.1). Age dependency ratio is higher for males than females (111.3 and 96.3 respectively) with a combined ratio of 103. There two hundred and sixty (260) homes in Ekumfi Aboano with an average of 13 – 15 people per home (Ghana Statistical Service, 2014; Global Brigades, n.d.).

5.5.3 Health

Like most areas in Ghana, the major health issue of Ekumfi Aboano is Malaria. There are however no medical facilities in the community but health centers are located at Otuam and Esaakyir about 10 and 30 minutes' drive away respectively. It has also been speculated that the lack of toilet facilities could result in typhoid, diarrhea, cholera and other infectious diseases (Global Brigades, n.d.).

5.5.4 Socio-economic Activities

The primary livelihood activity of the five communities is fishing and farming. However, other livelihood activities include petty trading, charcoal production, food vending, operation of drinking spot, hair dressing and dress making are complementary economic activities, which the population engage in.

Crop farming is not intensively practices in the area as envisaged. This is attributed to the poor soil fertility and productivity level for crop production. Consequently, the main crop cultivated by the people is tiger nut. Farming in these communities is seasonal primarily cropping tiger nuts.

Also, a number of socio-economic infrastructure are available within these communities and are listed to include the following:

Table 5-17 Socio-economic Activities and Infrastructure

ECONOMIC ACTIVITIES	COMMUNITIES				
	ABOANO	KONTANKORE	KOKODO	ETSIBEEDU	OTUAM
Hair dressing	2	6	5	3	8
Petty trading	8	3	9	2	23
Food vendors	4	15	9	3	43
Dress making	3	1	4	4	20
Drinking spots	7	11	7	3	16
Provision stores	5	15	2	1	71
Artisans	3	2	5	2	15
Church	7	2	5	4	18
Mosque	1	0	1	1	2
Toilets (KVIP)	3	0	1	1	3
Pipe borne water	2	3	4	4	12
Communication	4	0	2	0	9

Based on the field investigation conducted during the baseline study, the indications reveal that the socio-economic activities and infrastructure available in the communities mentioned include hairdressing, petty trading, food vendors, dress making, drinking spots, provision stores and artisans. Other facilities are churches, mosque, toilets (KVIP), pipe borne water and communication.

5.5.5 Community Structures

The table above represents the cumulative number of house type situated in the various communities: Aboano having total number of 67 houses, Kontankure with 84 houses, Kokodo with 60 houses, Etsibeedu 46 houses and Otuam 328 houses. Materials used in the construction of these houses are basically cement and sand, raffia and mud. Most of these are roofed with corrugated iron sheets except that of Kontankure which are mostly roofed with raffia fronds.

Table 5-18 Community Structures and their Make

	ABOANO	KONTANKORE	KOKODO	ETSIBEEDU	OTUAM
No. of houses	67	84	60	46	328
Cement	36	2	46	28	250
Raffia	--	2	--	18	2
Mud	31	80	14	--	76

5.5.6 Education

Educational institutions at Ekumfi Aboano offer training at the nursery, primary and junior high stages. The town has no Senior High School. The closest Senior High School is at Esakyer, 30 minutes' drive from Ekumfi Aboano. Teacher to student ratio is 1:60 and 60 % of population is literate (Global Brigades, n.d.).

Considering the District as a whole, the majority (48.9 %) of current school attendees are at the primary stage. At this stage, females represent a slightly higher proportion though overall males represent 10, 845 and females 9,729 of the population being formally educated. Approximately 26 % of the school going population is either in nursery or kindergarten while 0.6 % attended tertiary institutions (Ghana Statistical Service, 2014).

Table 5-19 Schools and Pupil/Student Population in Project Area

Location	Name of School	Departments	Boys	Girls	Total No. of Pupils
ABOANO	D/A Basic school	KG/ BASIC/ JHS 3	187	178	365
KONTANKORE	No school	--	--	--	--
KOKODO	D/A Basic school				
ETSIBEEDU	Etsibeedu D/A Basic School	NURSERY/KG/BASIC/ JHS 2	109	90	199
OTUAM	PRIVATE				
	Living Faith School	NURSERY/KG/BASIC/ JHS 1	150	120	270
	Otuam Prep. School	NURSERY/KG/BASIC/ JHS 3	185	172	357
	John Mensah Academy	NURSERY/KG/BASIC/ JHS 3	150	170	320
	Otuam Ammadiyah	NURSERY/KG/BASIC/ JHS 3	403	439	842
	Otuam Meth. Basic Sch	NURSERY/KG/BASIC/ JHS 3	282	257	539
	Otuam Sec. School	SHS 1			

5.5.7 Water and Sanitation

Challenges faced by Ekumfi Aboano regarding water resources include both quantitative and qualitative issues. Since pipe-borne water is scarce and underground water resources are economically unavailable due to salt water intrusion, community members mainly rely on rainfall and a fresh water pond. The latter is accessible by animals and also located near human excreta making it unsafe for consumption though it serves at a source drinking water usually without treatment. Defecation is primarily open-air (Global Brigades, n.d.).

5.5.8 Roads

The Accra – Cape Coast road runs 10 km north of the proposed site at Ekumfi to which a rural road of about 2 km connects to north of the site. There also exists an east-west rural road within the site region.

The detailed study methodology and description of the baseline are provided in the ***Independent Report 2: Socio-economic Impact Assessment***.

5.6 Cultural, Historical and Traditional Heritage

The Fantes constitute the dominant ethnic group in the Ekumfi District. They are believed to have migrated from the Brong Ahafo Region to the Central Region. During that period a group within the Fantses (the Ekumfis) decided to settle at the present Ekumfi District. They speak Fantse. The present traditional capital is at Ebiram where the seat of the paramount chief of the Ekumfi Traditional Council is located. The main festival of the District is "Ayerye" (Drumming) celebrated by most communities in the District including E. Aboano (Ghana Statistical Service, 2014).

There are notably varieties of historical resources, cultural and traditional heritage forming the conceptions, beliefs, reverence, obedience and faith of the people within the project area of influence, which contributes to the central point of the socio-cultural and economic well-being of the people.

A key historical feature is the common point demarcating the boundaries of the adjoining communities known as "Esiwodo" (See ***Figure 5-6***). This point has two heaps of specially selected stones on the sides of the pathway. The significance of this point is depicted by the reverence accorded to the site and the rituals performed by the settlers during festive seasons and also serving as the terminal point of each faction's Asafo company (Local militant group) during festive performances and displays.

Figure 5-6 A Picture Showing the Boundaries of the Adjoining Communities

This point of intersection of the boundaries of the communities lies within the project area and therefore the project development would potentially distort the state of the point and its traditional significance. The project would potentially have significant impact on this historical feature of the communities.

Also of significant value and interest to the settlers is the "Odaabiriadze" forest, which is a thicket covering an area of one acre (See ***Figure 5-7***). The thicket contains the "Odaabiri" tree which serves as a central point of prayer, libation and spiritual consultation for the settlers of the communities and especially during the Odwira (purification) festival.

Figure 5-7 A Picture Showing "Odaabiriadze" Forest

The thicket is situated at the boundary of the project site. Consequently, the development of the project would potentially cause the thicket to lose its original and traditional landscape setting and reverence (conception).

A stream referred to as "Nana Atsiribura" (Small River) has also been of significant reverence and importance to the settlers, particularly of Aboano community. The small water body, which is covered by mangrove lies in the middle of the project site. The stream serves as an important deity and provides a source of ritual solace and consultation to the settlers.

Figure 5-8 A Picture Showing Stream "Nana Atsiribura"

The stream and its location presents significant conflict of interest to the project development and therefore there is the need for extensive consultations in determining suitable options for common interest so as not to disturb the harmony the settlers find consolation. However, the Chief Priest has indicated the possibility of relocation of the god following appropriate consultations.

In addition, the traditionalists have also mentioned rumours of the existence of precious minerals on some part of the forest. Consequently, this presents another conflict of interest and could potentially create false impressions of annexing the resources.

Another historical feature is the "Abotreh" rock, a mass outgrowth of rocks in an exclusive thicket. The rock serves to provide the people a source of harmony for special prayers and traditional rituals.

The thicket lies close to the project site and therefore the development of the project is expected to have considerable adverse impact.

Finally, given the project would cover significant area of the sea and shoreline of the Aboano community, the fisher folks consider the situation as relocation of the activities of the fisher folks along the sea front including various rituals performed. There is also loss of territorial control and economic benefits to the Chief Fisherman and his subjects as fish landings may be relocated to other fishing territory.

The project therefore would impact on the traditional practices of the fisher folks and their activities. This means that new location(s) will have to be found and spiritual transfer of deities and their subjects will be required consequently. It has been indicated that such decisions will be taken only in consultation with the chief priests and or the different deities along the sea who are stakeholders in using the sea for ritual purposes.

The detailed study methodology and description of the baseline are provided in the ***Independent Report 4: Historical Resources and Cultural Heritage Assessment***.

5.7 Green House Gas Emissions

Greenhouse Gases (GHG) emissions in the atmosphere venting from anthropogenic sources are considered to be partly responsible for the global warming and causing global climate change. It is recognized that the average temperature on the Earth has increased by 0.7 degree Celsius since the start of the industrial revolution.

The United Nations Framework Convention on Climate Change (UNFCCC) is aimed to disclose country level contribution to the global GHG emissions as well as provide background to analyse emissions by sources.

The principal sources of greenhouse gases emission in Ghana are identified to include agriculture, forestry, energy (fuel combustion, mobile combustion & fugitive emission), Industrial Processes and waste. The details are listed in ***Table 5-20***.

Table 5-20 Green House Gas Emission Baseline

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total GHG Emissions Excluding Land-Use Change and Forestry (MtCO2e)	20.02	20.80	19.03	22.25	23.19	22.99	22.73	23.77	25.59	27.53	27.34
Total GHG Emissions Including Land-Use Change and Forestry (MtCO2e)	51.15	51.98	50.23	53.58	54.25	54.24	53.95	55.00	56.88	58.89	58.84
Total CO2 (excluding Land-Use Change and Forestry) (MtCO2)	7.72	7.45	6.97	7.41	8.74	9.38	8.76	10.09	11.70	12.52	12.81
Total CH4 (MtCO2e)	7.68	8.26	7.86	9.18	8.99	8.69	8.92	8.86	8.99	9.57	9.32
Total N2O (MtCO2e)	4.54	5.02	4.13	5.60	5.39	4.84	4.96	4.73	4.78	5.32	5.08
Total F-Gas (MtCO2e)	0.08	0.08	0.08	0.07	0.08	0.09	0.09	0.10	0.10	0.11	0.12
Total CO2 (including Land-Use Change and Forestry) (MtCO2)	38.76	38.54	38.12	38.62	39.70	40.41	39.86	41.26	42.94	43.83	44.19
Total CH4 (including Land-Use Change and Forestry) (MtCO2e)	7.74	8.31	7.89	9.26	9.06	8.84	9.00	8.90	9.03	9.61	9.41
Total N2O (including Land-Use Change and Forestry) (MtCO2e)	4.56	5.04	4.14	5.63	5.42	4.91	5.00	4.75	4.80	5.33	5.12
Energy (MtCO2e)	9.45	9.32	9.00	9.65	11.02	11.74	11.17	12.54	13.94	14.50	16.30
Industrial Processes (MtCO2e)	1.03	1.03	1.02	0.97	0.98	0.98	0.99	1.00	1.30	1.11	-
Agriculture (MtCO2e)	7.72	8.50	6.93	9.45	8.94	7.98	8.23	7.83	7.91	8.94	8.36
Waste (MtCO2e)	1.81	1.94	2.07	2.19	2.24	2.29	2.35	2.40	2.45	2.49	2.54
Land-Use Change and Forestry (MtCO2)	31.13	31.17	31.20	31.32	31.06	31.25	31.22	31.23	31.29	31.36	31.51
Bunker Fuels (MtCO2)	0.41	0.41	0.41	0.51	0.50	0.54	0.57	0.64	0.66	0.84	0.98
Electricity/Heat (MtCO2)	1.97	1.76	0.67	1.21	2.42	2.63	1.91	1.71	3.10	2.72	3.18
Manufacturing/Construction (MtCO2)	0.95	0.95	1.03	1.07	1.15	1.18	1.14	1.46	1.42	1.60	1.81
Transportation (MtCO2)	3.36	3.11	3.61	3.57	3.61	3.81	3.70	4.99	5.09	5.66	6.74
Other Fuel Combustion (MtCO2e)	2.90	3.23	3.41	3.52	3.57	3.84	4.14	4.11	4.05	4.24	4.29
Fugitive Emissions (MtCO2e)	0.27	0.27	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28

6 CONSULTATIONS

The Chapter presents the findings of all the consultations and engagements in relation to informing all stakeholders to be affected by the project, including the state agencies, District Assemblies and local communities and individuals etc. The dialogue covered the various issues of concern in relation to the potential impact of the project and the mitigation proposals to alleviate potential impact.

Consultations and dialogues commenced from project conception and through the inception of project development from Pre-feasibility preparation through feasibility phases. Furthermore, the consultations continued through the scoping exercise and subsequently through the preparation of the ESIA. The overall goal of the consultations and dialogues was to identify the potentially significant adverse environmental and social issues relating to the development, operation and decommissioning of the proposed 2X350 MW Supercritical Coal-fired Power Generating Plant situated at Aboano along the coast and address them adequately to prevent or minimize any potential adverse impact.

The key issues identified during scoping provided the basis for defining the scope of the ESIA and the approach to addressing the issues and informing especially the design of the environmental and socio-economic baseline studies to ensure sufficiently informing the process and all relevant stakeholders of the potential impact and implications and mitigation interventions.

6.1 Public Consultation and Disclosure Plan

The Public Disclosure Plan is prepared as part of ESIA for the 2X350 MW Supercritical Coal-fired Power Plant. The Public Disclosure Plan (PDP) presents a two-way communication process framework between the stakeholders and the Project; seeking to facilitate effective engagement with the stakeholders. The PDP is prepared in accordance with the Environmental Impact Assessment Guideline for the Energy Sector (EPA Vol 2) and the Performance Standard (PS) of International Finance Corporation (IFC) and according to Equator Principles.

The approach involved stakeholder analysis and planning, disclosure and dissemination of information, consultation and participation, grievance mechanism, and ongoing reporting to Affected Communities. The nature, frequency, and level of effort of stakeholder engagement are planned in accordance with the project's risks and adverse impacts.

The framework therefore seeks to:

1. Ensure appropriate technical and cultural approach to engaging with all key stakeholders;
2. Ensure efficient stakeholder information sharing process with affected stakeholders and other interested parties;
3. Provide sufficient opportunity for stakeholders to express their views and concerns;
4. Facilitate integration of stakeholder concerns and commitments into operations management systems and decision-making processes.

6.1.1 Stakeholder Identification and Analysis

Based on stakeholder identification and analysis, the key stakeholder groups, including those directly and indirectly affected, both positively and negatively, are listed in ***Table 6-1***.

Table 6-1 Stakeholder Identification

Stakeholder	**Type of Stakeholder**	
	Affected Party	**Interested Party**
Neighbouring communities/inhabitants		
Local Fishermen	✓	
Local Farmers	✓	
Local Administration	✓	
Chief and member of Ekumfi Aboano	✓	
Chief and representatives of Ekumfi Aboano, Kuntakure, Otuam and Estibaadu	✓	
Fisherman of Ekumfi Aboano	✓	
Ekumfi District Assembly	✓	
Institutional Agencies		
Ghana National Fire Service		✓
Ghana Grid Company Ltd	✓	
Electricity Company of Ghana	✓	
Ghana Water Company Ltd	✓	
Geological Service Department		✓
Meteorological Service Agency		✓
Hydrological Service Department		✓
Ghana Water Comp. Ekumfi District	✓	
Office of the President		✓
Chinese Embassy		✓
Regulatory Agencies		
Environmental Protection Agency (EPA)		✓
Ghana Ports and Harbours Authority (GPHA)		✓
Ghana Maritime Authority (GMA)		✓

Ministry of Power		✓
Ghana Investment Promotion Centre		✓
Public Utilities & Regulatory Commission		✓
Registrar's General Department		✓
Town & Country Planning Central Region		✓
Energy Commission		✓
Water Resource Commission		✓
Town & Country Planning Central Region		✓
NGOs		
Ghana Youth Environmental Movement (GYEM)		✓
Ghana Youth Climate Coalition (GYCC)		✓

6.1.2 Stakeholder Engagement Approach

The stakeholder Engagement Approach has been structured to consistently engage all the stakeholders both affected and interested parties and ensuring they are appropriately informed about the project development and progress during all the various phases of the project.

Furthermore, the engagement is expected to provide the appropriate channel for receiving information on the environmental and social performance of the project, obtaining feedback on the effectiveness of the environmental mitigation measures and management initiatives as well as dialoguing on grievances and issues of mutual interest between stakeholders and the project owners.

The stakeholder consultation and engagement process involved:

1. Consultations with identified key stakeholders during the planning phase of the project, which also formed a part of the scoping activities for the project to present the proposed Project and its related components and the initiation of the ESIA process.
2. Consultations and dialogue with the stakeholders have continued after the scoping phase to present reasonable details of the Project features and the identified impacts and proposed mitigation measures for discussions. The engagement further allowed stakeholders to submit and dialogue on issues of concern in relation to the aspects of the project.
3. As part of the ESIA process, a Public Hearing at the District level with Regional representation was planned to present the Project Features and Characteristics as well as discuss the issues of concern to stakeholders. On completion of the draft ESIA report, the reports would be exhibited at designated place for public review according to the Public Disclosure Plan.

4. On completion of the Final ESIA, a National Forum would be organized to present the final ESIA on the project.
5. The engagement process would continue with the stakeholders appropriately at all levels during the project development and implementation phase to ensure that the project technical and cultural integration has been effective.

6.1.3 Public Disclosure Plan

The Disclosure Plan aims at providing detailed information to the public about the proposed Project features and development activities; including the potential impacts, the planned mitigation and monitoring measures and the environmental management plan.

The plan is intended to offer complete access to the information, consequently after submission of the draft ESIA report to EPA an advertisement and notification to the public would follow to make the information available for public review for a period of 30 days.

The notification would be made in the daily newspapers indicating the places where the report is exhibited and available for public viewing, the period of exhibition and contact information.

The places identified for the exhibition of the report include:

1. EPA Head office and Regional Office
2. Ekumfi District Assembly
3. VRA Head office

6.1.4 Stakeholder Engagement Plan

The project would maintain consistent engagement with the stakeholders during the Project development and operation phases.

The primary objectives include:

- Ensuring all stakeholders are adequately informed about project progress and granted the opportunity to present concerns or grievances.
- Receiving feedback on the effectiveness environmental management measures and initiatives.
- Ensuring that grievance mechanism is well communicated and the grievances management has been transparent and effective.
- Project updates and progress information are available to all affected and interested stakeholders throughout the Project Life.

Stakeholder Engagement Tools

The tools for communication and engagement with the stakeholders would include letters and newspaper publications and advertisement, forum/meetings, dialogue and seminars/workshops.

The tools used in specific instances would vary with the different stakeholder groups based on the vulnerability stature of the group to ensure effective communication and engagement with the stakeholder groups.

Project information and communication would consider cultural appropriateness and ease of understanding in illustrations.

Stakeholder Engagement Participation

High level representatives of the Project would always participate in the sessions to assure of the full commitment of the company to the stakeholder engagement process, which building relationships and bridging any communication gap with the stakeholder representatives.

6.2 Stakeholder Engagement Activities (SEA)

There have been consistent consultations with various identified stakeholders during the pre-feasibility study stage of the project through the scoping study phase and the preparation of ESIA of the project.

More than 20 stakeholder groupings have been engaged in various consultation and dialogue mechanisms and are informed sufficiently and further educated on the development impact and implications of the 2x350 MW Supercritical Coal-Fired Power Plant Project.

The SEA included field work which spanned several months during which the following were achieved:

a) Stakeholder Identification and review;
b) Notifications of key stakeholders and publications in the print and electronic media; and
c) Seminars, workshops, fora and direct consultation meetings with the various stakeholders including national institutions and state agencies, local-level agencies and organisations and traditional authority and local groupings (including trade associations, social groups and NGOs).

6.2.1 Stakeholder Identification (Mapping)

The public consultation process involved stakeholder identification exercise undertaken to select key stakeholder groups and organizations, based on experiences in similar ESIAs in Ghana. These stakeholders were selected on the basis the potential interest in the Project and other concerns and information to provide insight into possible issues related to the project development and optimal performance. Furthermore, additional stakeholder groups were identified through the consultation processes and notifications.

The consultation was extensive and inclusive involving various identified public stakeholders, which can be categorized into three levels namely National, District and Local level consultations. The National Level consultation covered for Power Generation: EPA, Energy Commission, Ministry of Energy, GRIDCo, VRA, Forestry Commission (Wildlife Division), NGOs and Central Regional Coordinating Centre (Minister's Office).

A Stakeholder's Forum at Coconut Groove Hotel, Elmina

Stakeholder's conference at GS Plaza, Accra

The district level consultation engaged the District Assemblies and District Administration Agencies.

At local level the consultations engaged land owners, Chiefs and Leaders of trade associations and social groupings including the fishermen group, the farmers group, the women's group and the youth group. A comprehensive list of stakeholders consulted during the process is provided in Annex 4.

Other consultative groupings engaged during the process include the media and Environmental NGOs and Social NGOs.

The public consultation process was peaked at the public hearing programme held at the Ekumfi District Assembly.

6.2.2 Notification of Key Stakeholders

The stakeholders selected during the identification process were either consulted with via fora, face to face meetings, or via written comment and media publications and announcements. During the pre-feasibility studies, public fora were held in Accra which brought together key industry players who were informed about the proposed project. Also face –to- face meetings were held with some of the keys stakeholders to further sensitize them of the project since it is a novelty in Ghana.

At the scoping stage, meetings were mainly arranged with EPA, Energy Commission and the local communities and related groupings. A background information document (BID) was developed to further sensitize the local communities on the project and related development. The BID provided an overview of the Project and also outlined ways through which additional issues and comments could be raised with VRA/SEC and the ESIA team. At the EPA, a presentation was made to further sensitize the Agency and sought their concerns. A copy of the the BID is provided in ***Appendix 7: Background Information Document for Scoping Consultation***.

6.2.3 History of Public Consultation

A comprehensive representation of consultative meetings by category of stakeholders is as following:

Table 6-2 History of Public Consultation

Public Forums

Name	Date of Meeting	Location
Public Forum	13th April 2015	Accra
Pre-feasibility Study Review	15th July 2015	Accra
Public Forum	25th September 2015	Ekumfi
Media Conference	9th March 2016	Accra
District Public Hearing	31th March 2016	Ekumfi
Media Conference	11th May 2016	Accra

Key Stakeholders

Name of Stakeholder	Date of Meeting	Location
GRIDCo	19th January 2015	Tema
Geographic Service Department	30th January 2015	Accra

Meteorological Service Agency	30th January 2015	Accra
Hydrological Service Department	30th January 2015	Accra
EPA	11th February 2015	Accra
GPHA	16th February 2015	Tema
Ghana Maritime Authority (GMA)	11th February	Accra
Ministry of Power	25th February 2015	Accra
Ghana Maritime Authority	26th February 2015	Accra
Electricity Corporation of Ghana	20th March 2015	Accra
Ghana Investment Promotion Centre	20th March 2015	Accra
Public Utilities & Regulatory Commission	20th March 2015	Accra
Registrar's General Department	20th March 2015	Accra
Town & Country Planning Central Region	31th March 2015	Cape Coast
GPHA	1st April 2015	Tema
Energy Commission	8th April 2015	Accra
Ministry of Power	10th April 2015	Accra
GRIDCo	23rd April 2015	Tema
GPHA	13th May 2015	Tema
GMA	26th May 2015	Accra
Office of the President	14th July 2015	Accra
Chinese Embassy	14th July 2015	Accra
Ministry of Power	15th July 2015	Accra
GRIDCo	30th July 2015	Tema
Water Resource Commission	13th August 2015	Accra
GRIDCo	17th August 2015	Tema
GRIDCo	18th September 2015	Tema
Ghana Water Comp. Ekumfi Dist	23rd September 2015	Essakyir
ECG Ekumfi District	23rd September 2015	Essakyir
EPA	17th November 2015	Accra
Hydrological Service Department	2nd December 2015	Accra
EPA	8th December 2015	Ekumfi Aboano
Ekumfi District Assembly	8th December 2015	Ekumfi
EPA	18th February 2016	Accra
Ekumfi District Assembly	30th March 2016	Ekumfi

Town & Country Planning Central Region	5th April 2015	Cape Coast
Office of the President	19th April 2016	Accra
Energy Commission	26th April 2016	Accra
GPHA	28th April 2016	Tema
Electricity Corporation of Ghana	12th May 2016	Accra
Ghana Institute of Engineers	16th July 2016	Accra

Local Chief and People

People	Date of Meeting	Location
Chief and member of Ekumfi Aboano	25th Januray 2015	Apam
Chief and people of Ekumf iAboano	6th August 2015	Ekumfi Aboano
Chief of Ekumfi Aboano	26th August 2015	Ekumfi
Chief and people of Akwidaa	7th September 2015	Akwidaa
Chief and representatives (farmer, fisherman, youth and women) of Akwidaa	22nd October 2015	Akwidaa
Chief and representatives (farmer, fisherman, youth and women) of Akwidaa	23rd October 2015	Ekumfi Aboano
Chief and representatives of Ekumfi Aboano, Kuntakure, Otuam and Estibaadu	23rd December 2015	Takoradi Aboadze
Fisherman of Ekumfi Aboano	5th April 2016	Ekumfi Aboano
Chief and people of Ekumfi Aboano	21st April 2016	Ekumfi Aboano

NGOs

Name of Organization	Date of Meeting	Location
350-Reducing Our Carbon, Ghana Youth Environmental Movement	9th March 2016	Accra
350-Reducing Our Carbon, Ghana Youth Environmental Movement	8th May 2016	Tema

6.2.4 Consultative Meeting Agenda and Organization

Generally, each of the meetings followed this general format:

1. Introduction by the meeting facilitator, the stakeholders present VRA/SEC team and the ESIA team;
2. Brief description of the collaborating proponents;
3. Description of the proposed 2x350 MW Supercritical Coal-Fired Power Plant development and the components; and
4. Discussion of key issues and any information that may be relevant to the Project.

The stakeholders participating in consultative meetings during process duly registered their presence by signing attendance register. History of consultation, notes of the consultative meetings, attendance registers, written comments and correspondence received were collated and reviewed accordingly. Samples of the consultation records are provided in ***Appendix 8: Consultation Records***.

A semi-quantitative method together with professional judgment and experience was used to identify and extract the key issues raised by stakeholders during the scoping phase. A summary of these comments raised before and during the scoping consultations is as follows.

Ghana Maritime Authority (GMA)

a) GMA explained that they regulate the marine environment by providing Security Compliance Code in accordance with the International Ship & Port Security Code (ISPS)
b) VRA/SEC to submit the Port Plan for assessment and subsequent approval by the National Security Committee which must be endorsed by the Minister of Transport
c) GMA also advised that they have the mandate to provide navigational aids for vessels within the Ghanaian Maritime environment as such would offer such service for a fee to VRA/SEC.
d) GMA will assign the navigational chart to the port once GPHA gives their approval among other services.

Ghana Ports & Harbours Authority (GPHA)

a) GPHA indicated that since the port will be unique in terms of the cargo handled and may not duplicate any port cargo being presently handled in the Ports, they do not have any objection to the building of the terminal but due process need to be followed
b) GPHA advised that the feasibility as well as the scoping studies needs to be done comprehensively

c) GPHA also advised on the other stakeholders to be contacted such as the Survey, Metrological, Geological and Maritime Authorities
d) GPHA inform VRA/SEC that their services such as pilotage, towage among others are available for a fee.
e) GPHA suggested to VRA/SEC to build the coal handling terminal at their preferred location which will fit into GPHA's ports development programme for the Central region.

Energy Commission (EC)

a) The EC has no objection to the proposed project but advised VRA/SEC to use the best available technology to limit pollution.
b) EC also informed VRA/SEC to apply for a Wholesale Electricity Supply License which will allow for generate power

Consultative meeting with Energy Commission

Ghana Investments Promotion Centre (GIPC)

a) GIPC acknowledges the enormous potential benefits of the project including employment, skills development through technology transfer, foreign exchange savings etc
b) GIPC advised VRA/SEC to register under the GIPC Act 2013 (Act 865) to enjoy incentives such as custom duty exemption etc.

Ghana Water Company Limited (GWCL)

a) GWCL inform the VRA/SEC that Ekumfi Aboano and its environs receive water from the new Essakyir Water Treatment Plant that currently operates only 10% of its installed capacity of 14400m^3/d.
b) GWCL will conduct a technical assessment to determine the feasibility of supplying water to the proposed plant
c) GWCL requested for a joint site visit to be acquainted with the project

location

Environmental Protection Agency (EPA)

a) EPA requested for a site visit to be acquainted with the location
b) EPA suggested to VRA/SEC to look into different coal-fired power plant technology in generating electricity
c) VRA/SEC need to provide to the Agency the characteristics of the coal to be used and the fly ash
d) EPA cautioned VRA/SEC to critically assess the siting of the plant since the current location is only 0.6km away from the nearest village. Modelling need to be done to determine the extent of impact on the nearest village.

Presentation to EPA

Meeting with GRIDCo

Chief and Elders of Ekumfi Aboano

a) The issue of disposal of chemical waste into the marine environment
b) The effect of the exclusion zone round the coal handling terminal on the fishing activities
c) Compensation for lands acquired
d) The effect of blasting during construction and it effect on the building and also health of the people
e) Social benefits for the community such as free electricity, clearing of rocks to aid fishing etc.
f) Project will provide alternative source of income and employment for the youth in the community
g) Effect of breakwater construction on the shoreline including erosion and flooding

Consultative meetings with the Chief, Elders and the people of Ekumfi Aboano

Site Visit of Takoradi Thermal Power Station

As part of the community engagement, representatives of the chief, elders and people of Ekumfi communities made a reconnaissance visit to the Aboadze Thermal Plant to understand the nature of operation and environmental management situation.

A group photograph of the participants

Participants viewing a video of the proposed project and similar plants operated by SEC

Encounter with Media

The Proponents have held two engagements with the Media, which involved delivery of various presentations, followed by questions and answers session to inform the media appropriately and adequately. This is also in pursuit of the public awareness programme.

Encounter with the Media- March 2016

Encounter with the Media- May 2016

Dialogue with NGOs (G-ROC and GYEM)

Table 6-3 Dialogue with Concerned NGOs

ITEM	QUESTION	ANSWER
1	Can the EPA refuse a permit at phase 4 (Technical review of EIS documents.)?	Yes, EPA is mandated to do so.
2	Why is the installed capacity of the Solar Plants minimal?	Land –use issues limits the feasibility of increasing Solar generation in the generation mix.
3	Does VRA conduct internal audits?	VRA annually conducts internal audits at all its Thermal Power facilities
4	Does VRA comply with E.U. environmental Safeguards?	V.R.A complies with World bank environmental Safeguards which are equally as stringent as E.U environmental safeguards.
5	Since South Africa currently lacks coal, kindly clarify whether the envisaged suppliers of coal will be private or public sector operators in South Africa.?	South Africa does not currently lack coal. South Africa has approx.30.2 million tons of coal Reserve.
6	Will there be a difference between installed capacity and operating capacity of the Coal plant?	Normally installed and operating capacities vary due to environmental limitations such as ambient temperature.
7	What will be the difference between the installed cost and the operating cost?	Coal is the next cheapest source of energy after hydro generation.
8	How many trees will be planted around the plant?	Trees will be planted based on the requirements on the ground. VRA already has afforestation projects on-going and in terms of carbon trading, the carbon sink is not required to be at the same site emitting the carbons.
9	Will the fly ash not pose any negative impacts especially during transportation?	No negative impact is envisaged from the transportation of fly ash. The vehicles to be used for the transportation will be enclosed.

10	What is the distance between settlements and the proposed project site?	A buffer zone will be created between the Plant and its boundaries. Furthermore, the ash yard is to be located further away from community settlements.
11	How will the community benefit from the project?	Currently, the VRA Trust Fund disburses approx. $500,000.00 annually for various community related activities, thus, the affected communities will be assisted accordingly.
12	After reviewing the scoping report, review comments were submitted to VRA , however, there has been no response	An e-mail has been sent acknowledging receipt. In line with the EIA process, all relevant issues raised from the scoping report will be outlined and addressed in the Environment and Social Impact Assessment.
13	How is the project being funded?	China Africa Development Fund
14	In the event of an accident in the operation of the coal Plant; what happens?	There will be continuous monitoring of relevant operational parameters in order to identify errors. Furthermore, trip settings will be made available; hence, the system will automatically shut down in the event of system failure.

Dialogue with Concerned NGO including 350 Ghana Reducing our Carbon (G-ROC) and Ghana Youth Environmental Movement (GYEM)

Traditional Elders

Consultations with the chiefs and elders of the communities during investigation of the historical resources and heritage assets as well as related traditional practices of the communities.

Consultations with traditional elders on Historical Resources and Heritage Assessment

Public Hearing Programme

Following further consultations with EPA, EPA recommended that Public Hearing Forum would be necessary to appropriately create needed platform for broader community and other stakeholders interface with the Project Proponent; especially for broader disclosure and dialogue to address some key concerns of the stakeholders.

Consequently, with the support of EPA, a Public Hearing forum took place on the 31^{st} of May 2016 at the Ekumfi District Assembly community hall premise. In attendance were the chiefs, and sub-chiefs of the communities within the catchment area, queen mothers, elders and the people of the communities. Also attending, were various governmental agencies from the regional and district levels.

Public Hearing Forum at Ekumfi District Assembly Community Hall

Electricity Company of Ghana

The Project team engaged Electricity Company of Ghana in a consultative meeting, which introduced and dialogued on the project features, capacity and environmental controls.

Consultation with ECG – May 2016

Ghana Institution of Engineers – July 2016

Ghana Institution of Engineer

In response to an invitation from the Ghana Institution of Engineers, the Project Proponents presented the project features and the overall environmental performance indication to the membership of the Institution.

6.2.5 Main Inquires, Proposals and Concerns

The main inquires, proposals and concerns presented by Stakeholders during the consultation process and corresponding responses to the various issues are concluded in ***Table 6-4***.

Table 6-4 Main Issues Raised and the Various Reponses during Public Consultation

No.	Stakeholder	Location	Summaries of Main Inquiries, Proposals and Concerns presented by Stakeholders	Responses
1	**Neighbouring communities/inhabitants**			
	Fisherman of Ekumfi Aboano and Kuntankure	Ekumfi	Effect of the facility on the fishing operation, especially fish landing considering the type of fishing practiced	The project would provide additional alternate fish landing site
	Farmers of Ekumfi Aboano and Kuntankure	Ekumfi	Land acquisition and compensations issues	VRA/SEC would follow national regulation and good international practices
	Chief, elders and representatives of Ekumfi Aboano, Kuntakure, Otuam and Estibaadu	Ekumfi	Emission standards, blasting and consequent impact, effect of breakwater construction on shoreline erosion and flooding, disposal of chemical waste, exclusion zone and effect on fishing operation, property acquisition and compensations, employment generation for the youth and other social benefits.	Environmental standards including emissions would meet the national and international standards. Property acquisition and compensation process would also conform to the national and international standards and practices. Varied types of employment opportunities would be offered for hundreds of workers.
2	**Institutional Agencies**			
	Ghana National Fire Service	Accra	Fire safety requirements and certification process for the internal fire system and functional features	The project would conform to national and international fire safety requirements
	Ghana Grid Company Ltd	Tema	Grid connectivity issues and requirements for environmental permitting and grid construction	The Grid Impact Study has been completed by Gridco. Environmental Impact

No.	Stakeholder	Location	Summaries of Main Inquiries, Proposals and Concerns presented by Stakeholders	Responses
				Assessment study would be conducted.
	Electricity Company of Ghana	Accra	Project capacity and supply availability and reliability issues.	The project is design to have high availability and reliability
	Ghana Water Company Ltd	Accra	Local water supply system and operational capacity to supplement water requirements of the project as well as its feasibility.	Arrangement for a joint site visit.
	Ghana Ports and Harbour Authority	Tema	Discussion on the adequacy of existing port facilities to meet the requirements of shipping coal from South Africa to Ghana. Requirements for development of port facilities	Shipment requirements of coal for the operation of the Power Plant are higher than can be accommodated by the existing port facilities
	Water Resource Commission	Accra	Water-use demands for the development and operation of the power plant and supply requirements.	Regulatory requirements for water-use.
3	**Regulatory Agencies**			
	Environmental Protection Agency (EPA)	Accra	Request for site visit, consideration of best available coal-fired technology and providing information on the characteristics of the coal and fly ash. Concerns of minimum distance to neighbouring communities and the need for modeling to predict the extent of impact on the nearest village.	The project is adopting the best available technology given the design parameters and the environmental circumstances
	Ghana Ports and Harbours Authority (GPHA)		Conflict of the Operational features and requirements of the Terminal with the	The project is intended to meet the regulatory

No.	Stakeholder	Location	Summaries of Main Inquiries, Proposals and Concerns presented by Stakeholders	Responses
			mandate of GPHA. Due process for development of the Terminal reckoned with needed consultations with Survey, Metrological, Geological and Maritime Authorities. GPHA services and fit of the Terminal with GPHA's ports development programme for the Central region.	requirements of GPHA for the development and operation of port facilities and also international requirements for port safety
	Ghana Maritime Authority (GMA)		Regulation of the marine environment, provision of navigational aids for vessels and assigning navigational chart to the port.	Submission of Port Plan for assessment and subsequent approval
	Ministry of Power		Main design features of the power plant, operational and environmental requirements of the power plant.	The power plant design, operation and environmental requirements would meet national and international guidelines and standards.
	Ghana Investment Promotion Centre		Acknowledgement of the potential benefits of the project and advice to register under the GIPC Act 2013 (Act 865) to enjoy incentives such as custom duty exemption etc.	The project would consider registration under the GIPC Act.
	Public Utilities & Regulatory Commission		Main design features of the power plant, operational and environmental requirements of the power plant	The power plant design, operation and environmental requirements would meet national and international guidelines and standards
	Registrar's General Department		Registration requirements of the power plant facilities	Affirmed meeting the registration requirements

No.	Stakeholder	Location	Summaries of Main Inquiries, Proposals and Concerns presented by Stakeholders	Responses
	Energy Commission		No objection to the proposed project, deployment of best available technology to limit pollution and application for wholesale Electricity Supply License.	Affirmation to deploy the best available technology.
	Town & Country Planning Central Region		Zoning provisions within the project area and no conflict with the existing land use.	Project area is not particularly zoned.
4	**NGOs**			
	Ghana Youth Environmental Movement (GYEM)	Accra	Project development and community safety and relationship in particular relating to the youth	The project would develop elaborate public disclosure and engagement plan to address all relevant matters with community safety and relationship.
	Ghana Youth Climate Coalition (GYCC)	Accra	Environmental standards and carbon emission regulation and control intervention. Alternative source of power generation	Project would meet the highest international environmental and safety standards

6.3 Scoping Notice

According to the requirements under the EIA process in accordance to the Regulation 15 (1) of LI 1652, the Administrative procedure for scoping exercise required that the public is adequately and appropriately informed. Accordingly, notices are issued to relevant ministries, departments and agencies including Assemblies. Furthermore, advertisement was published in the Daily Graphic and the local radios.

6.3.1 Local Scoping Notice

The notice was placed in various locations within the communities and are listed to include:

a) Ekumfi District Assembly (Notice board)
b) Etsibeedu Palace (Delivered to the Chief)
c) Aboano Palace (At the entrance)
d) Hotel Facility at Aboano (Electric pole at the entrance of the hotel premise)
e) Aboano Village (Electric pole within the community)
f) Redemption International School, Aboano (Electric pole within the school premise)
g) Kontankure settlement (Electric pole within the vicinity)
h) Otuam (Assemblyman's office notice board)

Copy of the notice is attached as ***Appendix 9: Scoping Notice***.

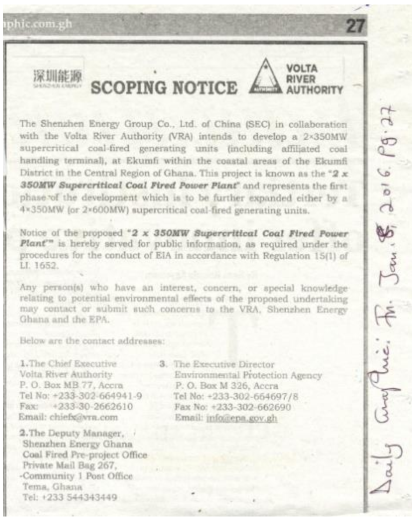
At the Aboano Palace

At the Aboano Village

At the Hotel Facility

6.3.2 National Scoping Notice

The notice was published on the national newspapers, including Daily Graphic (8th January, 2016), Daily Dispatch (10th January, 2016), and Ghanaian Times (11th January, 2016).



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深圳能源 SCOPING NOTICE VOLTA RIVER AUTHORITY

The Shenzhen Energy Group Co., Ltd. of China (SEC) in collaboration with the Volta River Authority (VRA) intends to develop a 2×350MW supercritical coal-fired generating units (including affiliated coal handling terminal), at Ekumfi within the coastal areas of the Ekumfi District in the Central Region of Ghana. This project is known as the "***2 x 350MW Supercritical Coal Fired Power Plant***" and represents the first phase of the development which is to be further expanded either by a 4×350MW (or 2×600MW) supercritical coal-fired generating units.

Notice of the proposed "***2 x 350MW Supercritical Coal Fired Power Plant***"" is hereby served for public information, as required under the procedures for the conduct of EIA in accordance with Regulation 15(1) of LI. 1652.

Any person(s) who have an interest, concern, or special knowledge relating to potential environmental effects of the proposed undertaking may contact or submit such concerns to the VRA, Shenzhen Energy Ghana and the EPA.

Below are the contact addresses:

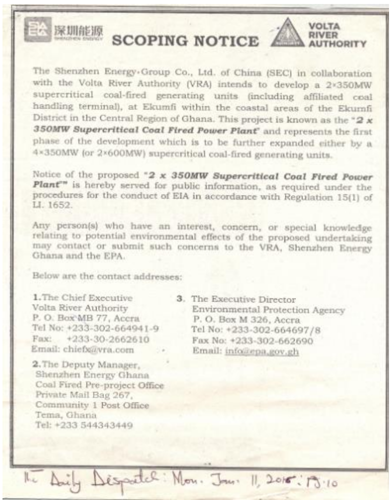
1. The Chief Executive
Volta River Authority
P. O. Box MB 77, Accra
Tel No: +233-302-664941-9
Fax: +233-30-2662610
Email: chiefx@vra.com

2. The Deputy Manager,
Shenzhen Energy Ghana
Coal Fired Pre-project Office
Private Mail Bag 267,
Community 1 Post Office
Tema, Ghana
Tel: +233 544343449

3. The Executive Director
Environmental Protection Agency
P. O. Box M 326, Accra
Tel No: +233-302-664697/8
Fax No: +233-302-662690
Email: info@epa.gov.gh

Daily Graphic: Fri. Jan. 8, 2016. Pg. 27

On Daily Graphic



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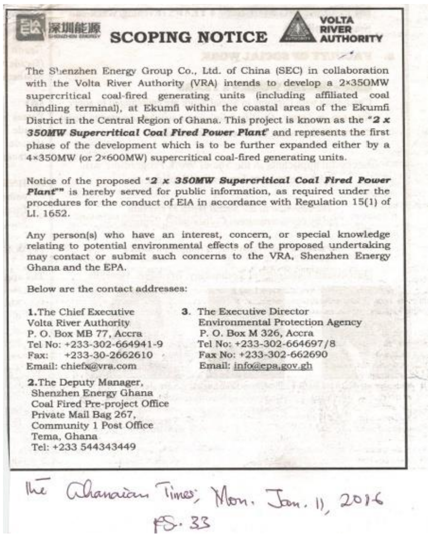
The Daily Dispatch: Mon. Jan. 11, 2016: Pg. 10

On Daily Dispatch



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Email: info@epa.gov.gh

The Ghanaian Times; Mon. Jan. 11, 2016 Pg. 33

On Ghanaian Times

7 IDENTIFICATION, ANALYSIS AND EVALUATION OF IMPACTS

The chapter provides detailed description of the occurrence and intensity of potential impacts of the proposed the development including the methodology used for the impacts identification and assessment. Information on potential, positive and negative impacts of the proposed undertaking from the environmental, social, economic and cultural aspect in relation to the different phases of the development of the undertaking is provided. The potential sources of impact have been carefully assessed and the identified potential impacts are described in terms of their nature, duration, magnitude, extent and frequency and categorized into all the phases of the project, particularly Pre-constructional, Constructional, Operational and Decommissioning Phases of the project.

The project would involve the development, operation and decommissioning of 2x350 MW supercritical coal-fired power plant with affiliated coal handling terminal. The development is envisaged to result in a number of potential impacts arising from activities related to the pre-construction, construction, operational and decommissioning phases of the project, which may affect the various receptors and the nature conservation interest within the area of influence.

7.1 Approach and Criteria

7.1.1 Identification of Potential Environmental and Social Impacts

The potential impact identification process involves comprehensive assessment of the potential source of impact of the project development and associated activities to predict and evaluate the potential effects on the physical, biological, social and cultural environment within the project area of influence. The process started with scoping the project's environmental risk and impact implications in its area of influence and has continued through the preparation of the ESIA.

The methodology involved objective evaluation of the incidence of identified impacts in relation to the nature, magnitude, duration, extent and frequency of occurrence. The review would then consider measures identified to avoid, minimize, mitigate or compensate for the adverse impacts. In the incidence of positive impacts, the review would consider measures enhancing the positive impact where possible. Furthermore, indications would be given relating to monitoring of relevant residual impacts and mitigation intervention to modify mitigation intervention and optimize overall environmental performance with minimal cumulative impact.

The methodology is therefore illustrated as following:

7.1.2 Identification of Residual and Cumulative Impacts

Residual Impact is considered as the impacts that remain following the implementation of mitigation measure, which may relate to each of the four key phases of the project namely design, construction, operation and decommissioning. On the other hand, Cumulative Impact is taken as the combined effect of individual impacts occurring when a receptor is affected by more than one impact during any phase of a development.

It has been widely recognised that project-level EIA alone cannot lead to comprehensive environmental protection or sustainable development [10]. Assessing the impacts of an individual project cannot always satisfactorily address the more strategic aspects of the project or the cumulative effects that may arise. Considerations of Strategic Environmental Assessment (SEA) are intently reviewed to address cumulative impact assessment and ensure that environmental consequences are addressed appropriately.

The environmental and social impacts are therefore assessed considering the environmental risk factors and parameters, identified impact implications in relation to the environmental resource/receptors. The assessment of impact therefore assesses the environmental parameter such as ambient air quality, noise etc, and evaluates the impact source in relation to the environmental resource/receptor such as water body, community, terrestrial environment, marine environment etc.

The process is depicted as following:

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[10]Guidelines for Landscape and Visual Impact Assessment 3rd edition – consultation draft

7.1.3 Impact Assessment Criteria

The assessment of impact would be based on quantitative and qualitative data available and based on experience. The qualitative risk assessment would be rated accordingly to the following impact classifications:

Table 7-1 Impact Classification

Classification	Rating
Significance	Magnitude, extent, duration
Intensity	Low, medium, high
Severity	Minor, Limited, Serious and Catastrophic
Probability	Low, medium, high
Frequency	Low, medium, high
Reversibility	Temporal or permanent

The significance of the impact is determined by the acceptability of a predicted impact to the resource or receptor and also the sensitivity (environmental value) and the magnitude of the impact (degree of change).

The approach therefore involves:

a) Assigning receptor sensitivity;
b) Assigning impact magnitude;
c) Assigning impact significance;
d) Predicting Cumulative Impacts.

Magnitude essentially describes the degree of change that the impact is likely to impart upon the resource/receptor.

The magnitude designations are as follows:

a) Positive
b) Negligible
c) Small
d) Medium
e) Large

The criteria for assessing the significance of impact consider:

a) The likelihood of exceeding project standards in relation to environmental quality and the National Environmental Quality Guidelines;

b) Impact affecting protected areas, valuable resources including nature conservation areas, rare or protected species, protected landscapes, historic features, livelihoods, important sources of water supply and other key ecosystem services;

c) Conflict with the Corporate Environmental Policy and Practice.

The significance of impact is rated as Negligible, Minor, Moderate and Major and may be determined using the impact matrix below:

Table 7-2 Significance of Impact

		Sensitivity / Vulnerability / importance of Resource /Receptor		
Magnitude of Impact	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major

Impacts on receptors can be varied and can be considered as negative, positive, direct or primary, indirect or secondary and cumulative, short term, long term and permanent. The importance and sensitivity of the receptors is defined by the relevance to its local, national, regional and international designation, its importance to local or wider communities, ecosystem function and economic value. The assessment takes into account the likely response of the receptor to change and the ability to adapt to and manage the effect of the impact.

Subsequent to the scoping study and assessment of identified potential, mitigation interventions have been considered and incorporated at the project design stage of project development process. The contemporary approach to impact assessment and mitigation adopted by the project placed emphasis on reduction of potential adverse impacts and optimizing potential benefits through appropriate design interventions.

Consequently, a number of design options providing mitigation measures to minimize identified potential impacts and environmental performance enhancement have been considered at the project design phase. The assessment would therefore define the impact and the mitigation measures in order to avoid or minimize the impact. Residual impact, if applicable would be defined and assessed using the impact significance matrix.

Currently, realization of the project would involve construction and operation periods, which entails activities that could have potential impact on environmental resources and receptors within the area of influence.

7.2 Pre-Constructional Phase Impacts

The pre-construction phase involves project pre-investment activities particularly including feasibility studies involving technical investigations, environmental assessment and preparatory works activities.

The technical investigations included marine and geotechnical investigations, hydrological studies, erosion survey, soil testing, and engineering investigations.

The process also involved consultations with various stakeholders, both the affected and interested groups, on the development of the proposed 2X350MW Supercritical Coal-fired Power Plant.

These pre-construction activities principally involve physical assessment and chemical analyses of test samples where necessary, which are in smaller quantities and localized sites. Consequently, the environmental impact and implications in relation to air quality and marine ecology would be negligible.

7.3 Constructional Phase Impacts

The construction phase would involve the following construction activities and developments:

a) Erection of temporary construction compound and storage areas for construction materials;

b) Site clearing, blasting and excavation works; removal of soils and debris of rocks and plants;

c) Installation and operation of construction machinery and equipment;

d) Construction of infrastructural and civil works, engineering constructional work and erection of structure and assembly of plant and machinery;

e) Repair and maintenance works of vehicles and machinery;

f) Transportation of materials;

g) Removal of site offices/compounds and final site clearing and disposal of constructional materials at the completion of construction works;

The activities are likely to result in environmental incidents, which potentially could impact of sensitive environmental resources/receptors.

7.3.1 Air Quality

Site clearing, earthworks including blasting and removal of soil and debris, operation of construction machinery and movement of vehicles including delivery trucks to and from the site would be the principal sources of air pollution generating fugitive dust emissions and exhaust emissions into the atmosphere. The principal pollutants would include sulfur dioxide (SO_2), nitrogen oxides (NO_X), particulate matter (PM), carbon monoxide (CO).

The impact of the identified emissions could be assessed based on the quantified fugitive dust emission and exhausted gas emissions levels generated by the activities. This could be determined by calculations using emission factors including manufacturers' specifications, which are internationally accepted and AERMOD software to models the dispersion and outfall. However, the amount of earthworks, number of construction machinery that would be deployed and the number of vehicles and their related movements are not specified at this stage. Consequently, it is difficult to determine quantitatively the level of air emission generated by the identified sources. In this regard, qualitative assessment is considered in determining the relative impact on ambient air quality.

The main receptors that are likely to be affected are the adjoining communities and residents. Also the generated dust and fumes could settle on the leaves of plants within the AOI to prevent photosynthesis from taking place effectively. The emissions potentially could affect the health of workers particularly the construction workers.

From available data and indications especially relating to the topography of the plant site the construction activities could be extensive and intensive (massive). However, the duration and extent would be limited as the operation would be confined to the initial stages of construction. In relation to the baseline ambient air quality situation of the AOI, the impact on air quality, particularly dust and exhaust fumes on the identified receptors could be rated as Moderate and the severity rated as low.

Construction areas would be fenced to limited dispersion of fugitive dust and other air pollutants. Furthermore, watering the grounds regularly as measure to reduce fugitive dust particles will be instituted and effective and efficient maintenance regime to improve operational performance of construction machinery and minimize exhaust emission would be in place. Additionally, movement of machinery and vehicles would be control by limiting the speed appropriately. Monitoring and management will be vital in these processes to ensure appropriate level of intervention mechanisms to achieve the expected mitigation and control.

The residual impact is expected to be minimal and therefore considered as minor and severity would be minor however occurrence is very likely.

7.3.2 Noise Impact

Earthworks and construction works including drilling, blasting, excavation, cutting, hammering, welding etc., operation of machinery and vehicles, movement of machinery and vehicles and increased human activities would be the identified principal sources of noise generation and nuisance.

Again, the amount of earthworks and construction works, number and nature of construction equipment and vehicles deployed and the related operation and movement and level of increased human activities are not specified at this stage. Consequently, determining the noise nuisance generated by the identified sources would be difficult and further modelling the noise nuisance to determine the extent and identifying the primary and secondary receptors would also be difficult.

Similarly, qualitative assessment is used to determine the relative impact on the potential receptors.

The key receptors include close by communities and residents and terrestrial fauna. The generated noise is also likely to cause nuisance to the workers and site visitors.

Similarly, information available reveal that the ambient noise level is expected to increase considerably beyond the baseline value resulting from the massive construction activities and both machinery operation and vehicular movement to and from the project site. However, the duration and extent would be limited especially to the initial stages of construction operation. Given that the construction area would be appropriately fenced and the machinery and vehicles are well maintained the residual noise level should be considerably abated and the impact significance could be rated as moderate while the severity could be rated as low.

Also, monitoring and management would be crucial to ensuring effective control intervention of the noise nuisance.

Potential noise impacts associated with the construction phase are illustrated in ***Table 7-3*** below.

Table 7-3 Potential Noise Impacts Associated with the Construction Phase

Activity	Potential impact	Magnitude of potential impact	Sensitivity of impact	Significance of potential impact	Need for Mitigation	Comment
Construction machinery and vehicles (bulldozers, excavators, loaders, dumpers, trucks)	Noise disturbance and annoyance	Medium	Local	Minor/ Negligible	Relevant	The source of noise may be the engine and exhaust. The potential impact is general disturbance and annoyance. The type of mitigation required includes proper operational procedures and operating sequence as well as effective engineering maintenance practices in accordance to manufacturers' instructions.
Compressors and generators	Noise disturbance and annoyance	Medium	Local	Minor/ Negligible	Relevant	The source of noise may be the engine, pulleys, valves and nozzles. The potential impact is general disturbance and annoyance. The type of mitigation required includes proper operational procedures and operating sequence as well as effective engineering maintenance practices in accordance to manufacturers' instructions.
Blasting, drilling, excavation, hammering and welding	Noise disturbance and annoyance	Medium	Local	Minor/ Negligible	Relevant	The source of noise may be the tool bit or entire machine. The potential impact is general disturbance and annoyance. The type of mitigation required includes proper operational procedures and

						operating sequence as well as effective engineering maintenance practices in accordance to manufacturers' instructions.
Cement mixing, materials handling and batching plant	Noise disturbance and annoyance	Medium	Local	Minor/ Negligible	Relevant	The source of noise may be the engine, filling, cleaning or impacts. The potential impact is general disturbance and annoyance. The type of mitigation required includes proper operational procedures and operating sequence as well as effective engineering maintenance practices in accordance to manufacturers' instructions.

7.3.3 Waste Water

Construction work and activities consume considerable amounts of water and also generate significant amount of waste water. The principal activities consuming water include concrete and construction works, ground watering and domestic applications. Waste water resulting from construction works and ground watering would be insignificant, if well managed and monitored. However, domestic sewage would be a key source of waste water generation.

Similarly, considering the scale of development and related operational requirements, the human activities would be significant as it is estimated that more than one thousand people would be involved in the constructional phase. Consequently, the domestic sewage could be very significant if not well managed and controlled, and could possibly pollute the receiving water bodies.

The principal receptor would be nearby surface water, the sea and likely the groundwater as the sewage may be drained in to these water bodies.

Given the scale of development and the deployment of labour, impact of the sewage discharged from domestic waste generated could be rated as moderate and the severity also as moderate.

Domestic sewage would be appropriately managed and disposed through the district assembly waste management system.

The residual impact is expected to be minor and the severity also rated as minor.

7.3.4 Solid Waste

Solid waste generation may result from construction debris and excavations including rocky materials, cleared vegetation as well as waste from packaging materials like cartons, wooden cases and pallets and domestic activities including food wrappers and leftovers. It is not anticipated that the large quantity of excavated materials would be reused in backfilling and port construction works.

Taking into account the baseline situation, it is expected that debris from construction works would be mainly grass vegetation and smaller rock boulders. Waste from packaging materials could be significant as well as waste from domestic activities.

The main receptor is the physical environment which would receive the waste materials. Indiscriminate dumping of waste would be avoided to ensure proper management and disposal of the waste generated using the municipal authorities and waste management system.

The impact on the receptor could be rate as minor and the severity could also be rate as minor.

7.3.5 Traffic and Transport Impact

Heavy duty vehicles and trucks carrying construction and building materials to and from the project site during construction may affect traffic flow and could even cause accidents on existing access roads, particularly the Accra – Cape Coast highway, which is relatively narrow.

Heavy equipment of 350MW coal-fired power generation unit mainly including boiler structural girders, STG stators and rotors, main transformer etc imported principally from China would be transported to the affiliated Material Offloading Facility. The units would then be transferred to flat transporters at the project site and transported to the to the erection site. This operation is not expected to have any potential impact on the traffic in the area

The main receptor could be the general public and particularly road users.

It is envisaged that larger proportion of the construction materials would be generated from the site through cutting and filling. Consequently, transportation of construction materials would be considerably limited. However, the principal impact is expected from transportation of heavy duty machinery to the project site. Escorts would be provided during such operation and where necessary. In addition, visibility of the vehicles would be greatly enhanced to improve being noticed at distance.

In general, the impact would be minor as the incidence is rather limited and can be managed and controlled effectively. Consequently, the severity would also be minor.

7.3.6 Occupational Health and Safety

Land preparation involving clearing and earthworks, constructions works, operation of the construction machinery and movement of vehicles and machinery would generate dust, fumes and noise that could lead to possible respiratory problems, hearing loss and other health related problems. Accidental tipping of construction materials and tools, use of power tools and accessories, falling gadgets, cuts from sharp objects as well as the inhalation of exhaust fumes from vehicles and equipment could cause potential injuries and harm to health of especially construction workers and neighbouring residents.

The main receptors are the construction workers and the residents of the adjoining communities.

Given the various mitigation interventions to mitigate dust generation, noise generation and exhaust gas emission and the limited duration of the impact, the impact could be rated as moderate and since the impact is considerably localized its severity could be rated as low.

Construction workers would be provided with appropriate and adequate personal protection equipment (PPEs) and ensure effective use of the PPEs. This practice is expected to improve personal protection considerable whiles minimizing residual impact considerably. The residual and cumulative impact could be rated as minor and severity also negligible.

7.3.7 Ecosystem

Construction works for the main power plant, ash storage yard and auxiliary facilities including residential facilities, roads, power evacuation grid lines, power supply lines etc. would require expansive land area; consequently, involving clearing of expansive vegetation. In addition, there would be considerable movement of construction machinery with related considerable noise generated.

Currently, the proposed site is covered with lush vegetation representing coastal scrub and grassland vegetation zones with isolated pockets of forest reserves and sacred grooves and span of farm. The Maritime vegetation comprising of strand and mangrove vegetation occupy the foreshore.

The baseline had revealed that the abundance and diversity of wildlife species in the area has reduced drastically over the past two decade. The relatively few species still occurring in the project area are notably mammal species. None of the mammal species identified were of conservation importance on the IUCN Red List of Threatened Species and the Ghana Wildlife Conservation Regulations.

The landscape portrays plant outgrowth on rock surface spread along the coastal line and the outgrowth forming thickets further inland. The thickets are sometimes used by the locals for shading.

Once the power plant is built, the site will be replaced by buildings and structures, which would be significantly alien to the existing inhabitants and the existing landscape character will be changed significantly.

The impact on plants during construction phase is potential loss of vegetation resulting from land clearing and levelling, which would destroy the original vegetation. However, the plants are not rare species, so only the quantity will be reduced and not extinct, consequently the impact would be partial, and therefore may not effectively cause regional ecological damage.

Wildlife species have been known to respond to disturbance and changes in their environment (habitat destruction or conversion, pollution, noise, etc) by either migrating, adapting or face mortality. Destruction of vegetation and disturbance from construction activities of the project is expected to cause the wildlife within the area to migrate to nearby habitats. This migration is however only possible when the removal of vegetation during construction is gradual. The highly migratory species such as birds encountered in the project area will migrate quickly and thus avoid any impact from the proposed project. But slow moving wildlife as well as young ones may not be able to avoid the impact and may therefore be destroyed by the project.

The proposed project site is noted to have very low fauna diversity and abundance. No species of international conservation interest was encountered in the project area. Three species of birds encountered in the area were completely protected by the Wildlife Conservation Regulation of Ghana.

The proposed project is therefore unlikely to have any significant adverse impact on the fauna of the area due to the very low faunal population and poor species diversity currently in the project area. Also the impact zone (foot print) of the project is limited and therefore not expected to have any significant impact on wildlife within the area of influence and beyound.

Mitigation measures to minimize identified potential impact are however proposed to include:

a) Construction activities for the project should commence during the dry season. Since some of the species encountered are expected to move out of the area during this period, consequently, any such activity of the project would likely have less impact, if any, on the wildlife of the area.

b) Particularly, construction activities of the project should not commence in the closed season as most mammal species are known to breed or tend to their young during the closed season (1st August to 1st December). Commencing outside this period is likely to avoid mortalities to fauna that may not be able to move fast because they are too young or pregnant.

7.3.8 Landscape and Seascape Visual Impact

The surrounding landscape is an important aspect of the lives of the people, contributing to individual, community and national identity and representing vast variety of benefits in relation to quality of life, well-being and economic activity.

For the purposes of this report, Landscape is interpreted as an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors.[11]

This interpretation brings to fore the inclusiveness of landscape depicting the relationship between people and place, which also provides the setting for the daily lives of the people. It results from the way the different components of the environment - both natural (the influences of geology, soils, climate, flora and fauna) and cultural (the historical and current impact of land use, settlement, enclosure and other human interventions) - interact together and are perceived. The perceptions of the people turn land into the concept of landscape”[12].

For any new development, there are some excitements, be it positive or negative, created within the surrounding people both direct and indirect beneficiaries. The mixed feelings as may be could be significant where the change becomes more significant to the landscape and therefore changing the physical setting of the people affected. These could generate hostility and apprehension of negative tendencies among the people as they foresee challenges to their socio-cultural, economic and political landscape in terms of physiological and psychological fluxes.

Sustainable Development for the purpose of this report is interpreted as Development that meets the needs of the present without compromising the ability of existing communities and future generations to meet their own needs. Development is central to the economic, environmental and social success of the community and therefore should be addressed positively and equally to protect, enhance and add value to the environment[13].

Landscape change is important to so many people, but attitudes to change in the landscape are complex making it particularly important that the nature of change and its effects are clearly communicated to the people who may be affected and to decision makers[14].

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[11]Landscape character assessment, Council of Europ, 2002
[12]Guidelines for Landscape and Visual Impact Assessment 3rd edition – consultation draft
[13]Guidelines for Landscape and Visual Impact Assessment 3rd edition – consultation draft
[14]Guidelines for Landscape and Visual Impact Assessment 3rd edition – consultation draft

At the construction stage, clearing land and blasting and removal of rock and also the related construction works of power plant and the affiliated coal handling terminal would contribute significantly to changing the land scape and sea scape of the site in particular. However, on completion of the construction distinct changes of the existing environments would emerge.

In addition, construction work for the erection of the 15 km grid line would involve clearing such expanse of land, which would also contribute significantly to changing the landscape along the route during the construction period.

The principal receptors that are likely to be affected are the local inhabitants especially who reside within the adjoining communities. Other receptors would be visitors who visit the beach for tourism and pleasure.

The visual impact of the constructions works of the plant, although is expected to be more confined to the plant site, could be significant considering the high level disorganization and apparent aesthetic appearance of the vicinity in relation to the baseline situation. However, this impact is also limited to the construction period as the landscape would further change into more organized edifice. The construction would therefore result in huge and giant structures and infrastructure arranged within the project site. Furthermore, the development of the coal storage yard would merge the coast and the sea after construction, which would also include the breakwater embankment and wharf facility. The landscape would therefore lose the shoreline view.

Regarding to the grid transmission lines the visual impact could be extended along the distance covered by the grid transmission lines. Similarly, the impact could be significant and rather extensive.

However, the benefits of development may be lost if attention is not given to managing the sensitivity associated with the impact of the people losing their traditional cultural and social identity. The mitigation is essential to minimize the residual visual impact.

Mitigation measures would involve fencing off construction areas during the construction operation to prevent exposure of construction area, which could contribute immensely to mitigating the likely impact of potential visual adverse effect. Due to the long time span for constructional activities, fences should be decorated with traditional symbols to create familiarity with the local inhabitants. In addition, arrangements to improve visual expressions of local landscapes should include the development of familiar landscapes, like known traditional trees to shield construction sites.

7.3.9 Green House Gas Emissions

Greenhouse gas emissions during the project construction phase would result from clearing of the vegetation and forest cover, which presently may act as carbon sinks, for the development of project structures, transmission lines and road infrastructure.

According to the baseline data, the vegetation and forest cover have already been cleared for farming activities, consequently the vegetation and forest cover cleared for the predevelopment of project structure would be rather limited. Therefore, the significance of the potential impact would be minor.

The project intends to develop elaborate greening scheme, which would include both trees and grasses with would cover estimated 20% of the plant area.

7.3.10 Land Acquisition

The Project is envisaged to acquire large tract of land estimated to 540 acres of land area for the development of infrastructure and installation of project facilities.

The potential impact would include loss of farmlands and related loss of income, displacement of residents with the acquired areas and potential family litigation resulting from management of compensation payment.

The land acquired would be appropriately compensated. The land acquisition and compensation payment process would follow the national regulatory requirements and international practices. The residual impact is expected to be minor, however the occurrence is likely.

7.3.11 Historical Resources Cultural and Traditional Heritage

The communities have varieties of historical resources, cultural and traditional heritage forming the conceptions, beliefs, reverence, obedience and faith of the people, which also contribute to the socio-cultural and economic well-being of the people.

The historical feature serving as the common point demarcating the boundaries of the adjoining communities known as “Esiwodo” situates within the project area. Therefore, the project development would potentially distort the state of the point and its traditional significance. Consequently, the project would potentially have significant impact on this historical feature of the communities.

The "Odaabiriadze" forest, which is a thicket covering an area of one acre is also of significant value and interest to the settlers. This thicket is situated at the boundary of the project site. Consequently, the development of the project would potentially cause the thicket to lose its original and traditional landscape setting and reverence (conception).

A stream referred to as "Nana Atsiribura" (Small River) also holds significant reverence and importance to the settlers, particularly of Aboano community. The streams lie in the middle of the project site and would generate significant conflict of interest to the project development. However, the Chief Priest has indicated the possibility of relocation of the god following appropriate consultations to find suitable options for common interest in order not to disturb the harmony the settlers. Furthermore, the consultations would consider rumours of the existence of precious minerals on some part of the forest in order to cater for the potential conflict of interest and attendant false impressions of annexing the resources.

Another historical feature is the "Abotreh" rock, a mass outgrowth of rocks in an exclusive thicket lying close to the project site and therefore the development of the project is expected to have considerable adverse impact.

Finally, the sea front of the Aboano community offer the fisher folks space for traditional and cultural practices including various rituals performed. Relocation of the seafront would potentially impact on the activities resulting in the loss of territorial control and economic benefits to the Chief Fisherman and his subjects. The project therefore would impact on the traditional practices of the fisher folks and their activities.

This means that new location(s) will have to be found and spiritual transfer of deities and their subjects will be required consequently. It has been indicated that such decisions will be taken only in consultation with the chief priests and or the different deities along the sea who are stakeholders in using the sea for ritual purposes.

7.3.12 Socio-economic Impact

The construction phase of the project would involve clearing of land sites, blasting and removal of plant and rock debris including top soil; hence agricultural land would be destroyed. These activities would therefore affect previous land owners as they would be required to cease all economic activities on the land and evacuate any assets on the land.

Similarly, the construction activities would also influence fishing operation at the beach area and consequently impact on the overall performance of the fishing operation. However, the impact on fishing operation is expected to be minimal as the construction activities of the power plant would more be cantered inland.

On the other hand, due to the influx of labourers and related construction workers, there is the likelihood of significant population expansion. Consequently, there would be attendant increased demand on social infrastructure and related facilities, including housing accommodation, utilities supply and health facilities. These demands and requirements would increase social cost including rent for accommodation. This would also contribute to expanding the both the economic power in terms of increased disposable incomes and market opportunities in the communities. More trading opportunities would be created for the indigenes. Additionally, the increased population and especially the boost in economic capacity of the project area would result in the potential for prostitution in the areas surrounding the project site. This therefore could lead to increased sexually transmitted diseases including HIV/AIDS, Gonorrhoea, and Syphilis etc.

The principal receptors are the local inhabitants and especially the economically active farmers and fishermen. Additionally, the general construction workers and supply contractors.

The key mitigation measures in addition to the positive benefits arising from the employment and economic opportunities include adequate and timely compensation payments to all relevant land owners and affected persons; provision of two fish landing sites on the eastern and western sides of the coal handling terminal; and provision of improved health infrastructure for the communities and utility infrastructure within the immediate vicinity. In relation to increase in prostitution and its attendant health risk, the project would make the needed provisions for appropriate education and sensitization programmes and interventions.

In the case of displacement of farmers and timely payment of compensations for land taken over by the project, the residual impact could be rated low for the farmers and other landowners. In the case of the fishermen, the development of two new fish landing sites situated appropriately for support the fishing operation of the local inhabitants also minimizes the residual impact on the fishermen. Regarding the larger communities, the impacts from increased cost of living and likely prostitution could be cumulative and would be rated as moderate.

Providing appropriate infrastructure where necessary for development of economic activities include food vendor and related activities.

7.3.13 Employment Generation

The construction process would generate employment for the youth within the Ekumfi District in particular and other areas in the country including the regional capital especially within the coastal areas in Ghana. The construction phase is envisaged to engage some 1000 workers in direct construction works including masons, carpenters, steel benders, electricians, welders and labourers while another 500 workers are expected to engage in indirect activities including drivers, security and cleaners.

In addition, considerable indirect employment could be generated through contractors and other service providers and suppliers.

Vendors would also emerge to provide food and catering services to the workers as well as trading in variety of items.

7.4 Operational Phase Impacts

A typical Coal-fired power plant burns coal to heat water in a boiler that creates high-pressure steam to turn turbine, which drives an electrical generator. Therefore, the operational phase of the project would involve operating the 2X350MW supercritical coal-fired power plant to generate electricity, which is finally evacuated via the national grid on the 330kV transmission line.

The operation entails receiving and discharging the coal into the coal stockyard, where the coal is prepared for boiler operation to produce steam, which is injected to drive the turbine and generator to generate the electricity. Seawater would be used for cooling the condenser adopting a once through circulation cooling system. The operation would utilize fresh water for steam generation and boiler make-up and also for domestic consumption, which is obtained from seawater desalination and public water supply system.

The operation of the plant would therefore generate flue gases, noise, effluent and other waste materials, which could have adverse impact of the environmental resources and potential receptors.

The effect of the operation of the plant is therefore envisaged to involve:

a) Atmospheric emissions
b) Noise and vibration generation
c) Affecting the marine environment including fishes, mammals and reptiles
d) Thermal discharge of process water, thermal plume and generation of waste water, sewage and other waste materials.
e) Environmental incidents and accidents (e.g. spillages, noise)

f) Abstraction of seawater and discharge of warmer seawater into the Sea
g) Impacting on people including workers, visitor, community and society at large.
h) Influencing the social and economic environment

7.4.1 Air Quality

During the operational phase of the power plant, the atmospheric emissions as a result of handling coal supply and burning coal in the boiler would impact on air quality. The atmospheric emissions would therefore include coal dust, the flue gas and the fly ash from burnt coal, which become the primary potential source of air pollution. Secondary sources of potential air pollution would exist and would include fumes from vehicular exhaust and other fume from the operation of auxiliary plant and machinery. For the purpose of this report, the secondary sources would be considered relatively insignificant. The principal pollutants would include sulfur dioxide (SO_2), nitrogen oxides (NO_X), particulate matter (PM), and greenhouse gases, such as carbon dioxide (CO_2)[15].

Environmental concern relating to flue gas emission is the ground level concentration of pollutants including Suspended Particulate Matter (SPM), sulphur dioxide (SO_2) and oxides of nitrogen (NOx).

Burning coal generate SO_2 pollution, which could contribute to formation of small acidic particulates ($PM_{2.5}$) that can penetrate into human lungs and be absorbed in to blood stream causing heart and lung diseases. SO_2 emissions also cause acid rain, which damages crops, forests and soils and acidifies lakes and streams. One of the most effective ways to reduce SO_2 emission is installing scrubber on the power plant smokestack[16].

NO_X pollution causes ground level ozone, or smog, which can burn lung tissue and can exacerbate asthma or make people more susceptible to asthma, bronchitis, and other chronic respiratory related diseases. Like SO_2, NO_X also contributes to acid rain and the formation of particulate matter. NOx pollution can be controlled by selective catalytic reduction, within the smoke stack using chemical catalyst to convert NOx to nitrogen and water[17]. Recently, low NOx combustion is also used to significantly reduce NOx emission in coal fired power plant through limiting NOx formation.

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[15]Environmental, Health, and Safety Guidelines, Thermal Power Plants, IFC, EHS Guideline 2008-"The primary emissions to air from the combustion of fossil fuels or biomass are sulfur dioxide (SO2), nitrogen oxides (NOX), particulate matter (PM), and greenhouse gases, such as carbon dioxide (CO2)"
[16]Ripe for Retirement, Union of Concerned Scientiest, November 2012
[17]Ripe for Retirement, Union of Concerned Scientiest, November 2012

There are three major types of combustion-related NOx; namely thermal, fuel bound and prompt. Thermal NOx is created by high flame temperatures in the presence of oxygen. Reducing peak flame temperature and restricting oxygen availability and exposure at peak temperature limits thermal NOx formation. Prompt NOx occurs through early reaction of nitrogen molecules in the combustion air and hydrogen radicals from fuel. Recent ultralow-NOx design have limited the generation of prompts NOx by minimizing the formation of sub-stoichiometric regions in the flame. Fuel-bound NOx is inherent in fuel and cannot be reduced, except through post combustion process[18].

In addition to causing particulate formation through SO_2 and NO_x emissions, coal plants directly emit particulates from their smokestacks in the form of fly ash. Incorporating precipitator or baghouse installation in smokestack contributes to reducing fly ash emission.

The controls would have many public health and environmental benefits such as reducing acid rain, smog, lung cancer, asthma, and diseases caused by mercury[19].

Currently, Boiler technology has improved significantly, particularly improving the combustion efficiency and overall performance and therefore capable of consuming less coal to generate the same heating. The development of pulverized supercritical and ultra-supercritical boilers has pushed the efficiency to 45% from as low as 33%.

Furthermore, additional technological improvements have incorporated additional facilities to improve overall performance of flue gas emission. According to IFC EHS, fuel choice, combustion technology and pollution control technology are interrelated and can optimize the project environmental performance.

This plant emission control configuration incorporates:

a) Choice of coal fuel giving preference to high-heat-content, low-ash, and low-sulfur coal[20];

b) Choice of combustion technology; adopting supercritical pulverized coal combustion;

[18]Environmental, Health, and Safety Guidelines, Thermal Power Plants, IFC, EHS Guideline 2008

[19]Ripe for Retirement, Union of Concerned Scientiest, November 2012

[20]Environmental, Health, and Safety Guidelines, Thermal Power Plants, IFC, EHS Guideline 2008

c) Electro-static Precipitator for removal of dust in flue gas;

d) Use of fuels with a lower content of sulfur and Seawater Flue Gas Desulfurization for removal and control of SO_2 in the flue gas[21];

e) Low NOx combustion[22];

f) Selective Catalytic Reduction (SCR) for removal of NOx in the flue gas;

g) Designing stack heights according to Good International Industry Practice (GIIP) to avoid excessive ground level concentrations and minimize impacts, including acid deposition[23].

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[21] According Environmental, Health, and Safety Guidelines, Thermal Power Plants; recommended measures to prevent, minimize, and control SO_2 emissions include: (1) Use of fuels with a lower content of sulfur where economically feasible and (2) Seawater FGD with up to 90% removal efficiency) depends on the capacity of the plant, fuel properties, site conditions, and the cost and availability of reagent as well as by-product disposal and utilization, IFC, EHS Guideline 2008.

[22] According to IFC EHS, formation of nitrogen oxides can be controlled by modifying operational and design parameters of the combustion process (primary measures). Additional treatment of NOX from the flue gas may be required in some cases depending on the ambient air quality objectives.

In accordance to Good International Industry Practice (GIIP), recommended measures to prevent, minimize, and control NO_X emissions include:

- Use of low NO_X burners with other combustion modifications, such as low excess air (LEA) firing, for boiler plants.
- Installation of additional NO_X controls for boilers may be necessary to meet emissions limits; a selective catalytic reduction (SCR) system can be used for pulverized coal-fired, oil-fired, and gas-fired boilers or a selective non catalytic reduction (SNCR) system for a fluidized-bed boiler

[23] For specific guidance on calculating stack height see Annex 1.1.3 of the General EHS Guidelines. Raising stack height should not be used to allow more emissions. However, if the proposed emission rates result in significant incremental ambient air quality impacts to the attainment of the relevant ambient air quality standards, options to raise stack height and/or to further reduce emissions should be considered in the EA. Typical examples of GIIP stack heights are up to around 200m for large coal-fired power plants, up to around 80m for HFO-fueled diesel engine power plants, and up to 100m for gas-fired combined cycle gas turbine power plants. Final selection of the stack height will depend on the terrain of the surrounding areas, nearby buildings, meteorological conditions, predicted incremental impacts and the location of existing and future receptors.

On the other hand, the operation of heavy trucks and machinery and equipment could also be potential source of emission of exhaust fumes and dust particulate.

The baseline results of the 16-days background ambient air quality monitoring carried out from 5-21 January 2016 within the plant site is presented in ***Table 7-4*** (Harmattan Season). The reported concentrations were largely lower than the Ghana EPA ambient air quality guidelines but with TSP and PM level attained 26.19% and 76.06% respectively of the guideline standards, attributed possibly to the severe harmattan at the time of the measurements.

Table 7-4 Background Ambient Air Quality Concentrations at Proposed Project Site during Harmattan Season

Date	CO (µg/m3)	NO_2 (µg/m3)	SO_2 (µg/m3)	TSP (µg/m3)	PM_{10} (µg/m3)
Average	**714.31**	**4.19**	**62.15**	**60.23**	**53.24**
EPA Guideline	10000.00	150.00	150.00	230.00	70.00

Air quality modelling has been performed with the objectives of determining:

i. Background ambient air quality

ii. air emission dispersion and the maximum ground level concentrations of NO2, SO2, & PM and maximum emission outfall locations;

iii. the air emission dispersion modelled maximum ground level concentration results against the Ghana EPA guideline; and

iv. Evaluate the impacts of the modelled results and provide recommendations for air monitoring campaign based on the dispersion results

Accordingly, the following ground level concentration (GLC) values of three criteria pollutants (NO_2, SO_2, and PM) were obtained.

Table 7-5 Maximum Ground Level Predicted Concentrations from AERMOD Dispersion Modelling and Impact Analysis

	NO_2			**SO_2**			**PM**	
Average Period	**1-hr**	**24-hr**	**Annual**	**1-hr**	**24-hr**	**Annual**	**24-hr**	**Annual**
Project Impact (µg/m³)	90.41	13.47	5.50	102.00	15.20	6.62	3.28	1.43
Outfall Point, Easting (m)	740411.72	739911.72	740611.72	740411.72	739911.72	740611.72	739911.72	740611.72
Outfall Point, Northing (m)	576455.57	576955.57	577255.57	576555.57	576955.57	577355.57	576955.57	577355.57
Monitored Background Conc. (µg/m³)	4.19	4.19		62.15	62.15		60.23	
Total (Maximum GLC)	94.60	17.66	—	164.15	77.35	6.62	63.51	1.43
EPA Guideline	400	150		900	150	80	230	75
EPA Guideline Consumed (%)	23.65	11.77	—	18.24	51.57	8.28	27.61	1.91
Process Contribution to EPA Guideline (%)	22.60	8.98	—	11.33	10.13	8.28	1.43	1.91
Maximum Allowable Process Contribution (µg/m³)	263.87	97.21	—	558.57	58.57	53.33	113.18	50.00
Exceedance of Maximum Allowable Process Contribution (µg/m³)	-173.46	-83.74	—	-456.57	-43.37	-46.71	-109.90	-48.57
IFC/WB Ambient Guideline (µg/m³)		150	100		150	80	230	80
IFC/WB Guideline Consumed (%)	—	8.98	5.50	—	10.13	8.28	1.43	1.79
25% of EPA Guideline (µg/m³)	100.00	37.50	—	225.00	37.50	20.00	57.50	18.75

Note:

The emission dispersion modelling adopted ambient air quality concentration during the harmattan season for the background base condition. This is to present the worst case scenario for the ground level concentration.

The calculated cumulative concentration values were compared with the Ghana EPA Ambient Air Quality Guidelines and IFC/WB Guideline for Thermal Plant.

The modelled results indicated the maximum ground level concentrations (GLCs) for NO_2, SO_2, and PM from the coal-fired power plant will not present any significant adverse short- and long-term impacts on the receiving environment; given the stack height of 180 m and should the proposed controls/mitigation interventions be implemented.

The daily and annual total maximum Ground Level Concentration of sulfur dioxide (SO_2) are predicted to be 77.35μg/m^3 and 6.62μg/m^3 respectively, with the process contribution to EPA guideline appreciably low being 10.13% and 8.28% respectively. Similarly, the one hour and daily total maximum Ground Level Contribution of NOx predicted as 94.60μg/m^3 and 17.66μg/m^3 respectively and with process contributions to the Ghana EPA Guideline for NO_2 noted as 23.65% and 11.77% respectively for one hour and 24hour periods respectively. The highest daily predicted project contributions to the Ghana EPA guideline was noted for NO_2 (13.47 μg/m^3) at the maximum outfall point 728m at X: 739911.72; Y: 576955.57 and 968m at X: 740611.72; Y: 577255.57 northeast of the stack for daily and annual respectively). The maximum daily Ground Level Contribution for PM (63.51 μg/m^3) was predicted at 728m (X:739911.72; Y: 576955.57) northeast of the proposed stack location and ranked lower than the Ghana EPA and WB/IFC guidelines of 230 μg/m^3.

Invariably, the predicted daily and annual maximum environmental concentrations for all the modelled pollutants would not exceed both the Ghana EPA guideline and also IFC/WB ambient guideline at stack height of 180m.

Independent Report 5: Air Emission Dispersion Modelling Report presents the isopleths of the predicted NO_2, SO_2 and PM_{10} emission impacts for the various averaging concentration periods. The orientation of the maximum concentrations is at mainly the northeast of the stack and moderate incidence at SW notably for PM10 (especially for the 24-hour averaging period). The location of the maximum predicted plant emission outfalls is largely influenced by meteorological parameters, topography and emission source parameters (terrain elevation, building orientations, stack parameters, etc.) and emission rate. Prevailing winds are predominantly blowing from SW directions to the northeast. Therefore, the isopleths show that the annual ground level concentrations are affected mostly by the prevailing wind regime. The maximum emission outfall is predicted to occur at 1081m NE from the stack.

The significance of the impact is assessed based on details of the general approach to control of air quality provided in the '*EHSy Guidelines*' (World Bank

IFC, 2007). Furthermore, assuming that the process contributions as a result of the emissions from power generation can be considered acceptable if:

- A process contribution is <25% of the relevant air quality standard; and
- The process contribution does not result in predicted environmental concentrations (PEC, i.e. the sum of the process contribution and the existing background concentration) that exceed the appropriate standard.

Per the WB/IFC '*EHSy Guidelines*', the SO_2, NO_2 and PM contribution from the proposed Power Plant would not exceed the 25% of the Ghana EPA Guideline.

Conclusively, should the project implement the designed stack configuration with the height of 180m and other emission control mechanisms considered, the dispersion model indicates relatively low process contributions and consequently low adverse impacts to the receiving ambient environment/receptor is predicted for NO_2, SO_2, CO & PM_{10} emissions.

7.4.2 Green House Gas Emissions

A principal component of the emission from the combustion of coal is Carbon Dioxide, which is a major Green House Gas (GHG) under the UN Framework convention on Climate Change[24].The project is projected to emit 3.69 millon tonnes of Carbon dioxide into the atmosphere annually.

The project has considered CO_2 emission control interventions to include:

a) Adoption of low carbon coal. The choice of design coal for the operation of the boiler considered achieving the optimum balance between high energy value and minimal carbon content of coal. (The energy value of coal increases with the carbon content whiles the moisture content and the combustions efficiency increases and decreases respectively with lower carbon content.) Bituminous coal has carbon content of 45 – 85% and the design coal is selected to have carbon content of 66%.

b) Co-firing with biomass (a carbon neutral fuel) as a means of reducing the potential environmental impacts associated with the combustion of fossil fuels has been considered. However, it is reckoned that though the potential of co-firing coal with biomass to assist reduction in greenhouse gas emissions is valuable; also the potential of decreased boiler efficiencies, significant maintenance problems and increased

[24]Environmental, Health, and Safety Guidelines, Thermal Power Plants, IFC, EHS Guideline 2008

maintenance cost due to higher boiler corrosion, slagging and fouling issues and also increased boiler down-time present considerable challenges to adopting co-firing with biomass as suitable option in this project (the option is evaluated in details in Chapter 4).

c) Adoption of higher energy conversion technology, Supercritical boilers, to improve the overall energy conversion efficiency and thereby reducing emission and burning lesser coal fuel per kWh electricity generated.

d) Ensuring that the initial design efficiency performance of the combustion system is maintained throughout the operation of the plant using high performance monitoring techniques, appropriate design and efficient maintenance regime of the combustion system.

e) Low carbon offset interventions and programme including:
   - Carbon sequestration potential of VRA Reforestation Programmes within Volta lake
   - Offsets from VRA's Combined Cycle Projects
   - Offsets from VRA's and SEC's Renewable Energy Programmes (Solar/Wind)
   - Carbon Accounting Programme beginning 2016

7.4.3 Noise Impact

The principal sources of noise generation during the operational phase would mainly be the operating machinery and equipment, which would include Primary Air Fan, Forced Draft Fan, Induced Draft Fan, Air Compressor, Transformer, Turbine and auxiliaries, Generator, Crusher, Mill, Pumps, Aeration Fan, Coal Handling Machines and Conveyors, the Boiler and auxiliaries etc.

The sound levels are shown in ***Table 7-6***.

Table 7-6 Sound Level of Major Noise Sources

Equipment	Sound Level (dB(A))
Turbine	90
Generator	90
Crusher	95

Medium Speed Mill	90
Primary Air Fan	95
Forced Draft Fan	100
Induced Draft Fan	90
Aeration Fan	90
Air Compressor	95
Transformer	75

Additionally, vehicle and associated transporters would contribute to the noise generation. Furthermore, metal fabrication works and maintenance processes would also contribute to the noise source as well as the human activities within the project area.

Principally, the noise generated would be operational level noise, which may be significant and however, the noise is not expected to create significant nuisance. Nonetheless, the noise is not envisaged to impact any significantly on the receptors, which primarily would include the nearby residence and the workers and visitors within the factory premises. The plant layout arrangement has been configured and considered setting the potential noise sources remote from the identified receptors, which are arranged further south and to the western end of the plant area. Additionally, the plant is situated within an area recommended for industrial area zoning,

The plant design also considered the use of noise control measure such as noise isolation and enclosure designs, adopting the use of silencers and mufflers where possible as well as sound absorbers including vegetation to minimize and control the ambient noise at the plant and other sensitive areas.

A noise transmission modelling study has been conducted for the operational phase of the project based on the identified noise sources and the specified noise level of these machinery and equipment. The modelling result is expected to help evaluate noise concentration and noise management options.

According to a 48-hour noise monitoring of the nearby communities during the dry and wet seasons, there were marginally higher noise levels in the dry season than the wet season in these communities except for Otuam community. The reported noise levels in all the community exceeded Ghana EPA residential noise limit of 55 dBA and 48 dBA for day and night time respectively.

The summary of the results of the modelled noise predicted indicatethe maximum noise level was 83.19 dBA occurring at (X 76211.4, Y: 40397.65), which lies within the power plant boundary. The model noise results are presented in ***Table 7-7*** and ***Figure 7-1***.

Table 7-7 Predicted Noise Levels of Sensitive Receptors (Main Communities)

Receptor Location	Predicted Noise Level (dBA)			EPA Guideline	Compliance Status
	Modelled Noise (dBA)	Average Background Noise (dBA)	Predicted Noise (dBA)		
Aboano community	10	62.52	62.52	55	Not Compliant
Etsibeedu Community	38	64.68	64.69	55	Not Compliant
Otuam Community	12	61.85	61.85	55	Not Compliant
Kontankore Settlement	20	59.56	59.56	55	Not Compliant

Note: Sound Pressure Levels (SPLs) are based on long scale thus the addition of the modelled and background noise levels for the predicted noise were calculated using the formulae:

$$SPL_T = 10 \times \text{Log}\ \Sigma\ 10^{\ (SPLi/10)}$$

Where: SPL_T is the total sound pressure level, and SPL_i is the ith sound pressure level to be summed

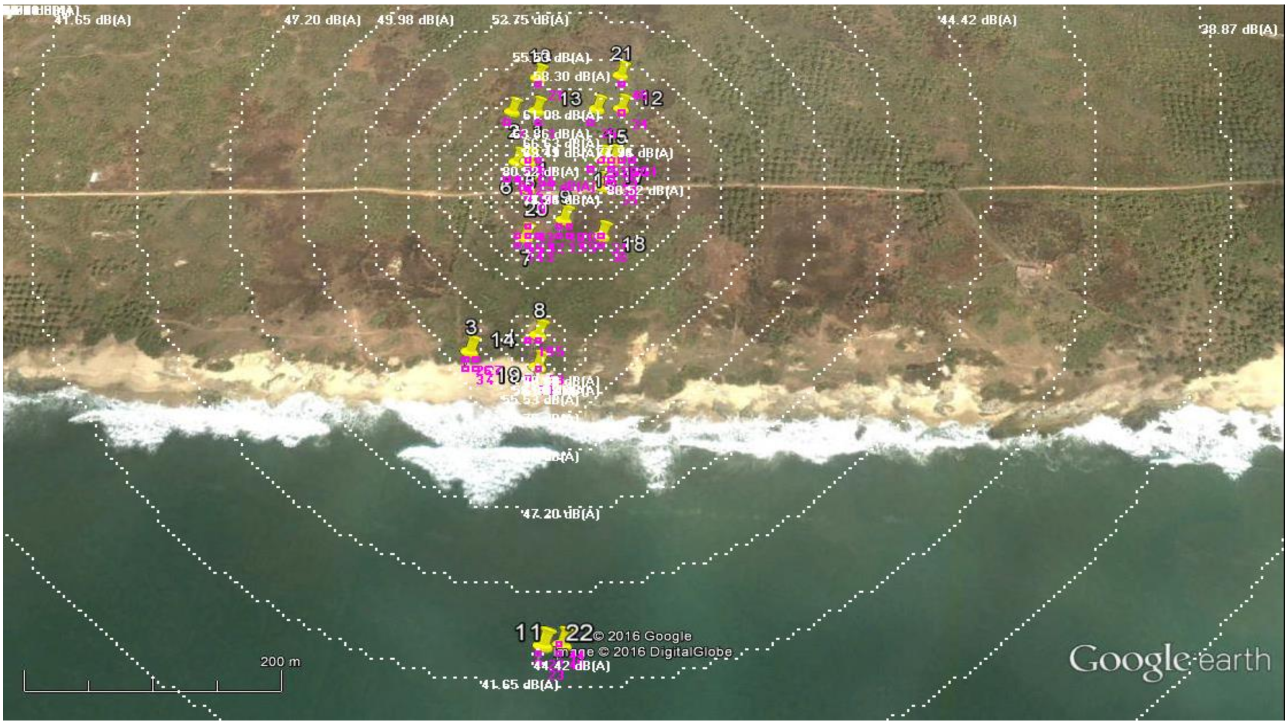

Figure 7-1 Isopleth of Modelled Noise Levels from the Proposed Site

The significance of the noise emission and the severity of the residual impact is can be considered as effectively controlled if maintenance practices are well managed accordingly to the manufacturers recommended preventive maintenance schemes. Consequently, the probability of occurrence of the nuisance would be rated unlikely and hence the residual impact would be low. Also the cumulative impact would be low.

In general, the principal receptors of the noise nuisance are the workers of the company and contractors and also the inhabitants of the immediate neighbouring communities as the noise is envisaged to be largely confined to the project area. However, moving truck and other related vehicular movement are further likely to transport the noise along their routes, which would therefore potentially impact on inhabitants of the communities situated along the route.

The specific measures considered to reduce and control the impact of noise include:

a) Specification of noise requirements for equipment manufacturers and if necessary, acoustic absorbent, muffler, and so on will be considered.

b) Incorporating mufflers at steam vent of boiler and strengthening management during operation of the power plant to reduce the emission frequency of boiler; avoiding emission at night when required, so as to reduce the noise influence on surroundings.

c) Prevention of vibration and impact during pipeline design to reduce vibration noise; improving the flow field of air duct and fluid transportation to reduce air power noise.

d) Reasonable overall planning for the plant area is conducted to ensure arrangement of high-noise equipment far from the areas sensitive to noise.

e) Developing plantation of arbor and shrub within the plant area, especially noise sources and along the roadside as green belt to reduce noise level.

f) The plant is designed with seawater once-through cooling system, without drenching noise as conventional cooling tower.

To reduce the impact of plant noise on the nearby village in the west, optimization has been done during the overall layout, plant front area-auxiliary and ancillary facilities area – main power block area are arranged from west to east. Plant front area could act as noise buffer zone, and main power block area with centralized noise sources is arranged in the other side far from the village. It is predicted that the contribute value of plant noise to the village will be within the limit of noise standard.

The primary mitigation measure would be appropriate and effective maintenance of the machines especially maintaining well lubricated moving parts and replacing worn out parts in timely fashion. The significance of the noise emission and the severity of the residual impact is can be considered as effectively controlled if maintenance practices are well managed accordingly to the manufacturers recommended preventive maintenance schemes, parts likely to create significant level noise nuisance would be eliminated. Consequently, the probability of occurrence of the nuisance would be rated unlikely and hence the residual impact would be low. Also the cumulative impact would be low.

The detailed study methodology and description of the baseline are provided in the ***Independent Report 6: Noise Dispersion Modelling Report***.

7.4.4 Seawater

The operation of the coal-fired power plant would involve utilizing the seawater for cooling in a once through circulation system to condensate steam from the turbine used to generate the electricity; and further a portion of the seawater is used for removal of sulphur dioxide from flue gas in the seawater FGD system. Additionally, the seawater is demineralized and used for boiler make-up and other service water including coal and ash handling.

Once Through Circulation Cooling

The operation of the once through circulation cooling system involves abstracting seawater from the coal handling terminal basin through sub-sea intake conduits, passing through the condenser unit and discharging the process effluent to the western side of the breakwater through sub-sea discharge channel structures. The discharge channel would run 100 metres offshore to discharge in a 3 metre depth through a number of outlets.

Once the seawater circulates through the plant, it is heated and would be discharged through the discharge channel back into the sea with elevated temperature. The designed resulting thermal discharge would be at maximum temperature of 8.83^{0}C above the ambient seawater temperature determined for design purpose as 26.3^{0}C. It is important that the thermal discharge is designed to ensure that discharge water temperature does not result in high seawater temperature exceeding relevant ambient water temperature outside the established mixing zone.

According to IFC EHS Guideline, the mixing zone is typically defined as the zone where initial dilution of a discharge takes place within which relevant water quality temperature standards are allowed to exceed and takes into account cumulative impact of seasonal variations, ambient water quality, receiving water use, potential receptors and assimilative capacity among other considerations

The abstraction and discharge of seawater with elevated temperature and chemical contaminants such as biocides or other additives used in controlling fouling agents, are likely to affect marine organisms and the marine ecosystem, including phytoplankton, zooplankton, fish, crustaceans, shellfish, and many other forms of marine aquatic life. Also marine organisms may be drawn into cooling water through the intake structures and could be impinged, entrained or entrapped in the cooling water system.

In the case of impingement, entrainment or entrapment, the marine organisms may be harmed or killed, consequently, there are concerns relating to the impact of abstraction of the cooling water and the location of the intake structure regarding habitation of endangered or protected marine organisms and active local fishery operations.

Measures to prevent, minimize, and control environmental impacts associated with water withdrawal considered the habitation of threatened, endangered, or other protected species as well as the fisheries within the hydraulic zone of influence of the intake, reduction of impingement and entrainment of fish and wide screens.

A plume Modelling has been conducted to effectively determine the thermal plume characteristics (maximum discharge temperatures) and appropriate discharge characteristics (flow rates), which ensures effective mixing and minimum impacts of the thermal plume on the marine ecological resources.

Measures to control impacts of the once through circulation cooling system involve:

a) Appropriately designing the intake to allow side entry and controlled the intake velocity to such low rate, less than 0.3m/s, conforming to IFC Guidelines for Thermal Power Plant (2008); stating that the velocity generally considered suitable for the management of debris is 0.3m/s with wide mesh screens[25]. The intake structure is therefore designed to be a low velocity side entry (LVSE) intake.

[25]Environmental, Health, and Safety Guidelines, Thermal Power Plants, IFC, EHS Guideline 2008

b) The intake is also arranged to have a velocity approximately perpendicularly aligned to the direction of the current to prevent organisms being entrapped or drawn up consequently minimizing entrapment, impingement and entrainment resulting from intake abstraction.

c) The intake is provided with grid drum to screen and prevent entrapped flora and fauna and debris entering the system

d) Intake and discharge channels are arranged to prevent obstruction of ships and anchors.

Measures to prevent, minimize and control thermal discharge and associated impacts from the once through circulation cooling system includes:

a) The adoption of multiple outlet conduits to diffuse the thermal discharge;

b) Adjustment of the discharge temperature, flow, outfall location, and outfall design to minimize impacts to acceptable level (involving extension of the length of discharge channel before discharge for pre-cooling or change location of discharge point to minimize the elevated temperature areas);

According to Takoradi International Company's once through cooling system to serve T1 and T2, the once through circulation cooling system presented considerable environmental benefits, based on the lower temperature of the cooling water, the improved cooling of the steam turbines (higher thermal efficiency) and increased outputs of the steam turbines. The benefits realized centre on improving generation efficiency, increasing electricity supply and limiting air emissions and climate change.

These benefits have been illustrated as following:

- Increased outputs of the steam turbines as improved cooling leads to better steam turbine performance thus providing additional output energy without any increase in fuel consumption. Generally, improved cooling allowed the power plants to operate at an overall higher efficiency. Consequently, the once through circulation cooling would contribute to increased output efficiency of the power plant. In this regard, additional energy is available creating additional capacity to supply additional population and representing additional installed capacity.

- The increased energy output of the turbines without increased fuel use creates reduction in CO_2 emissions per unit power output and also the displacement of additional thermal generation requirement to supplement installed capacity creates further reduction in flue gas pollutants emissions and CO_2 emission. CO_2 reduction can be significant and may be estimated by the calculation from thermal efficiency increase and generation displacement.

- Reduced maintenance costs of all civil and mechanical steel components, resulting from the elimination of seawater cooling towers, which causes salt spray and corrosive saline air conditions.

- Noise reduction due to the absence of cooling tower fans.

- Socioeconomic benefits. As a result of construction a number of short term employment opportunities for local skilled labour will arise. The once-through CW system will abstract and discharge up to a maximum of 16 m3s-1 of seawater from structures located approximately 2 km from the shoreline.

Flue Gas Desulfurization

A portion of the seawater after cooling the condenser would be used for the flue gas desulfurization process, after which the seawater from the FGD units (86300m^3/h）is aerated and mixed with brine from desalination of seawater （125m^3/h）and discharged.

The FGD process involves seawater and flue gas encounter causing the seawater to absorb $SO_2$and becoming more acidic effluent. This is further aerated adjusting the pH to become more neutral (The pH value of the discharge seawater into the sea would be above 6.0). The seawater then flows into seawater recovery system by gravity and mixes with the fresh seawater from the condenser and returns to the sea.

Fresh Water Production

Fresh water is produced from desalination of seawater. The resulting brine is mixed with the seawater front the FGD unit (86300m^3/h).

The seawater effluent from the desalination process may have higher concentration of salinity and may cause potential pollution.

Potential Effect on Aquatic Organisms

The Once through Circulation Cooling System may potentially cause impingement and entrapment of aquatic organisms, especially depending on seasonal factors, current characteristics, weather conditions and abstraction velocity. The principal organisms would include planktons and juvenile and larval fish due to their inability to entrain and therefore may remain impinged. The potential impact could then be significant in relation to the marine ecological resources.

In an Environmental Impact Statement for the Once Through Cooling System to Serve T1 and T2, achieving an approach velocity of less than 0.3m/s would allow a large majority of fish to be able to avoid entrapment [26] (Defined maximum approach velocities which will enable fish to escape at different water temperatures - Turnpenny 1988). Accordingly, the average seawater temperature of 26.3^{0}C at Aboano would enable many juvenile species have sufficient swimming speed to avoid entrapment as swimming speed increases with increasing ambient temperature.

The intake is situated in the port basin accordingly, it is expected to vary the current ecological factors especially the marine flora and fauna. According to the baseline studies

According to the modelling, the CW would be abstracted at a maximum rate of 0.3 m^3/s and a nominal rate of 0.2 m^3/s. The Thermal discharge rate is determined as 2.08 m^3/s. The plume characteristic therefore demonstrates the near-field dispersion characteristics of the heated effluent discharge using CORMIX3 indicates a thermal plume that is positively buoyant, which is fully mixed in the near-field and continues as vertically mixed into the near far-field. The temperature at the edge of the mixing zone is predicted as 2.97^{0}C. The results also suggest that the water quality standard of 3^{o}C above ambient water is achieved at plume location of 86.05m.

The detailed study methodology and description of the baseline are provided in the ***Independent Report 7: Thermal Plume Modelling Report***.

Environmental sensitivity analysis suggests there would be minimal impact on marine biota within the vicinity of discharge.

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[26]Environmental Impact Statement, Takoradi International Company, Jacobs 2010

7.4.5 Effluent

The wastewater streams in the power plant would include waste water from ash handling and storage runoff; boiler blow down and cleaning waste, back wash from demineralization plant, wastewater from ESP wash, cleaning wastewater, storm drains, laboratory wastes and wastewater from water purification and waste water treatment units and Sewage and other sanitary wastewater.

The effluent in the plant mainly include domestic sewage water (8 m^3/h), coal waste water (18 m^3/h), oil wastewater (4 m^3/h) etc.，they will be treated separately, and then reused for green in the plant, or humidifying ash and slag, water cleaning, etc.

The principal contaminants would include coal and ash particles and related heavy metals including arsenic mercury and lead; chemicals including fluorine, chlorine, biocides and other related chemicals for managing the quality of cooling water; and traces of fuel oil and lubricants.

The waste water including coal and industrial waste water and washing waste water would be treated completely in a waste water treatment system to control acidity and neutralize chemical load including elimination of metals such as chromium and zinc from chemical additives used for controlling fouling and other organisms and suitable steams would be recycled before eventually drained out. This is intended to minimize and control wastewater effluent generation from the plant by conserving and reducing water utilization.

In the case of spray of ash piles, there is the potential of runoff water infiltrating into the ground. The ground is protected by protective liner of composite geo-membrane, which has performance of 1.0×10^{-7}cm/s permeability coefficient equivalent to 1.5m thick clay soil.

7.4.6 Solid Waste

The Coal-fired power plant would generate significant solid waste in the form of coal ash residues from the coal fuel during the operational processes. The waste includes fly ash, bottom ash and boiler slag. The bottom ash including slag is coarser and heavier. Consequently, fugitive fly ash may cause pollution to the surrounding. Ash and slag generated from the coal fired power plant would be stored only temporarily.

The ash residues may contain heavy metal and some organic compounds or potentially hazardous materials. Measures to prevent, minimize, and control the volume of solid wastes from thermal power plants Recycling of CCWs in uses such as cement and other concrete products, construction fills (including structural fill, flowable fill, and road base).

The Raw Coal Ash, which is the by-product of the power plant produced after combustion of the coal, would be sorted into Fine Ash and Coarse Ash. The Fine Ash can be applied in cement industry, concrete batching stations and large-scale building projects. The Ghanaian Standard for cement production GS 22:2011, permits the utilization of the coal ash in cement production. The provision is stated as: "Minor additional constituents if present shall be one or more of limestone, granulated blast furnace slag, pozzolana, pulverized-fuel ash (fly ash) or other fillers".

The use of coal as in construction works is already practiced in Ghana. Recently, huge volumes of coal ash were imported into Ghana from China for the construction of the BUI Hydroelectric Dam project.

The Coarse Ash and Slag may also be grounded into Fine Ash by the Grinding System, or be made into light-weight aerated concrete blocks according to the demand of the market.

Two Chinese companies have already signed MOUs with the project to develop comprehensive utilization of the coal ash in Ghana.

7.4.7 Soil

Soil erosion is a potential impact considering the project characteristics, against the existing local soil erosion situation, natural conditions and other factors. The project will adopt specific effective prevention measures to ensure prevention and minimal erosion of the soil caused by the project.

The project has considered balancing the earthworks to ensure that the net impact is minimal, development of green designed areas and instituting temporary soil erosion prevention measures during the construction phase. The land scape is set in three steps with drains suitably placed on the periphery to facilitate and ensure effective drainage of storm water from the site.

The development of green designed areas considered multiple factors including as production process, building layout arrangement, dispersion of harmful gases, underground pipeline arrangement and the local climate and soil condition. Local low shrub and climbers would be selected and arranged to effectively protect soil surface.

Soil contamination is also a potential impact considering the project features especially coal storage, coal ash storage and waste water disposal and chemical and hazardous substances management. These materials potentially could seep into the soil leaving heavy metals and other hazardous substances in the soil and further into ground water.

Coal and ash storage facilities are constructed with appropriate protection at the bottom, including composite geo-membrane set on the surface of bottom and inside slope for the ash storage yard to prevent permeability of hazardous substances.

7.4.8 Hazardous Waste

Hazardous materials may include solid, liquid, and gaseous fuel-based waste and water treatment chemicals; and equipment and facility maintenance chemicals (e.g., paint certain types of lubricants, and cleaners). Spill prevention and response guidance is important to manage emergencies related to handling of these materials.

Once the ash is soaked by rainfall, harmful element in ash may seep into the underground water, resulting in significant impact implications on the ground water.

Measures to prevent, minimize, and control hazards associated with hazardous materials storage and handling include the use of double-walled, underground pressurized tanks for storage.

7.4.9 Traffic

During operation of the power plant, traffic nuisance is expected to be negligible as therefore would be very limited transportation.

7.4.10 Fire Hazard

Potential sources of fire include gas leakage from the hydrogen generation plant and generator cooling system, oil spill and leakage from the transformer cooling system, lubricating oil system and light diesel oil storage for the boiler back-up start fuel.

7.4.11 Occupational Health and Safety

The operation of the power plant may cause a number of occupational health and safety risks and impacts, which may include:

- Non-ionizing radiation

- Heat
- Noise
- Confined spaces
- Electrical hazards
- Fire and explosion hazards
- Chemical hazards
- Dust

The receptors for occupational health and safety impacts include direct workers of the power plant and sub-contractors visiting to work at the plant.

Operation of the power plant and affiliated facilities may cause dust and noise nuisance to the worker and could lead to respiratory problems and hearing lose respectively. Additionally, ground level gas concentration may be significantly high and could cause nuisance to the worker.

Non-ionizing radiation

The workers would have higher risk being exposed to electric and magnetic fields (EMF) due to consistent proximity to electric power generators and related equipment and the high-voltage transmission lines.

Occupational EMF exposure should be prevented or minimized through the preparation and implementation of an EMF safety program including the following components:

a) Identification of potential exposure levels in the workplace;

b) Use of personal monitors during working activities;

c) Training of workers in the identification of occupational EMF levels and hazards;

d) Identification and establishment of safety zones, differentiating between work areas with expected elevated EMF levels compared to those acceptable for public exposure, limiting access to properly trained workers.

Implementation of risk and safety measures would include action plans that seek to any address potential or confirmed exposure levels that exceed reference occupational exposure levels developed by international organizations such as the International Commission on Non- Ionizing Radiation Protection (ICNIRP), the Institute of Electrical and Electronics Engineers (IEEE).

Furthermore, personal exposure monitoring equipment would be arranged to warn of exposure levels that are below recommended occupational exposure reference levels. In addition, the action plans would address occupational exposure by (1) limiting exposure time through work rotation, (2) increasing the distance between the source and the worker, and (3) adopting using shields.

Heat

Exposure to heat may occurs during operation and maintenance of combustion units, pipes, and related hot equipment.

Prevention and control measures would include:

a) Ensure the integrity of insulation of combustion units, pipes and related hot equipment by regular inspection and maintenance the identified facilities;

b) Ensuring all work areas are adequately ventilated to reduce heat and humidity;

c) Reducing the time required for work in elevated temperature environments and ensuring access to drinking water;

d) Adopting the use of shield in areas necessary;

e) Suitable warning signage developed at appropriate high temperature areas and

f) Personal protective equipment (PPE) as appropriate provided and effectively used at all times

Noise

Occupational health and safety risk may arise due to workers' exposure to identified noise sources. Measures to prevent, minimize, and control occupational noise exposures would include:

a) Identifying and marking high noise designated areas, typically including areas with noise levels greater than 85 dBA;

b) Ensuring the appropriate PPEs are used at designated areas at all times;

c) Providing sound-insulated control in appropriate areas;

d) Ensure appropriate operational and maintenance regimes to prevent and minimize noise generation.

Confined Spaces

Specific areas for confined space entry may include coal ash containers, turbines, condensers, and cooling water towers. These areas would be appropriately designated with specific operational instructions.

Electrical Hazards

High voltage transmission lines and related equipment present electrical hazards for workers of the power plant.

Measure to prevent, minimize, and control electrical hazards include:

a) Deactivation and proper grounding of live power equipment and distribution lines according to applicable legislation and guidelines whenever possible before work is performed on or proximal to them;

b) Use of voltage sensors in areas of high voltages;

c) Consistently providing specialized electrical safety training to workers working with or around exposed components of electric circuits. The training would include areas of basic electrical theory, proper safe work procedures, hazard awareness and identification, proper use of PPE, proper lockout/tagout procedures, first aid including CPR, and proper rescue procedures.

Fire and Explosion Hazards

Thermal power plants store, transfer, and use large quantities of fuels; therefore, careful handling is necessary to mitigate fire and explosion risks. In particular, fire and explosion hazards increase as the particle size of coal is reduced. Particle sizes of coal that can fuel a propagating explosion occur within thermal dryers, cyclones, baghouses, pulverized-fuel systems, grinding mills, and other process or conveyance equipment. Fire and explosion prevention management guidance is provided in Section 2.1 and

Recommended measures to prevent, minimize, and control physical hazards at thermal power plants include:

a) Use of automated combustion and safety controls;

b) Proper maintenance of boiler safety controls;

c) Implementation of startup and shutdown procedures to minimize the risk of suspending hot coal particles (e.g., in the pulverizer, mill, and cyclone) during startup;

d) Regular cleaning of the facility to prevent accumulation of coal dust (e.g., on floors, ledges, beams, and equipment);

e) Removal of hot spots from the coal stockpile (caused by spontaneous combustion) and spread until cooled, never loading hot coal into the pulverized fuel system;

f) Use of automated systems such as temperature gauges or carbon monoxide sensors to survey solid fuel storage areas to detect fires caused by self-ignition and to identify risk points.

Chemical Hazards

Exposure of workers to chemical increases the health and safety risks. Additionally, workers may be exposed to chemical fumes, which could also lead to respiratory problems.

Measures adopted to prevent, minimize, and control physical hazards at thermal power plants include appropriate education of workers on handling and management of chemicals in accordance to MSDS and providing appropriate information as contained in the MSDS; use of suitable personal protective equipment including nose mask and goggles.

Dust

Dust generated during operational activities may contain potentially harmful substances and exposure of workers could create health and safety impacts leading to respiratory problems.

Measures to prevent, minimize, and control occupational exposure to dust within and outside the plant would involve adopting of dust controls within area of fugitive dust (e.g., exhaust ventilation, watering and ramping etc) to keep dust below applicable guidelines has been adopted. Where the residual dust level is significantly high worker would be required to use appropriate personal protective equipment, which may include as required nose mask and goggles.

Community Health and Safety

Community Health and Safety risk would relate to traffic safety, noise and vibration, dust, emission and water consumption. The risk to the community include exposure to high residual emissions, noise and vibration nuisance, non-ionizing radiation generated by the power transmission grid, visual impact of changed landscape, and traffic nuisance and the consequence potential health risk due to degraded air quality, visual impact and resulting emotional stress and increased public insecurity.

The influx of migrant workers both national and international into the communities presents considerable social challenges including social vices. The community is likely to experience upsurge of sex workers and attendant health hazards including HIV AIDS.

The community would also experience increased community population and attendant demand on community health and educational facilities

7.4.12 Socio-Economic Impact

During the operational phase, the project would create direct or indirect employment opportunities for both skilled and unskilled labour, enhance skills development and good localization opportunities. It is estimated that the project would provide some 1,000 people with jobs including engineers, technician including mechanics, electricians, welders, account officers, secretaries, cleaners and security officers.

Furthermore, the project would contribute to providing meaningful job opportunities for the locals within the local communities and economic empowerment for the surrounding communities.

The project would also provide additional electricity to the national grid; contributing to meeting electric power shortfall in Ghana and promote local economy development while stimulating the development of related industries such as manufacturing, transportation and commerce.

The project would also contribute to the foreign direct investment inflow and contribute directly and indirectly to national revenue generation and export.

Furthermore, the project would create immigration and resultant demographic changes in the local communities; and could result in cultural changes including possible conflict arising from immigration and tourism issues.

Additionally, the project would create provisions for infrastructure development such as roads, schools and health facilities; impact on the potential land use in the area and also boost local economy.

7.5 Decommission Phase

The decommissioning phase of the project would involve dismantling and removal if installations and associated development facilities where practicable. The activities would include:

a) Removal and management of power plant facilities and infrastructure where appropriate including re-shipment of components of the power generating plant;

b) Removal and management of pipelines and channels for cooling water;

c) Removal and management of switch gears and pylons;

d) Demolition of buildings and civil structures including offices, production structures and accommodation and management of the disposal.

The impacts likely to arise out of these activities are:

a) Increased levels of noise;

b) Disposal of unserviceable equipment parts and machinery;

c) Increased vehicular transportation of serviceable components and equipment;

d) Disposal of on-site infrastructure debris;

e) Occupational hazards;

f) Socio-economic (workers' layoff and compensations, loss of power generating capacity and power supply).

There would be significant impact on road surface when heavy plant components are being transported to the disposal site other than reshipment. Since this would be done with trailers by road, their heavy axle loads would adversely affect road surfaces and shorten the life span of the road pavement. The transportation operation would also affect traffic flow during the process.

Table 7-8 Identified Environmental and Socio-economic Receptors

RECEPTOR	**COMMENT**
Physical Environment	
Atmosphere	The atmosphere within and around the plant site, especially the coal storage yard, ash storage yard and ROW of grid.
Soil	The soils of areas in which construction and operational activities are to occur.
Seabed	Potentially affected by channel construction as well as the water intake facility.
Hydrogeology	The hydrogeology (i.e., groundwater) in the area in and around where construction and operational activities are to occur.
Water column	The seawater quality in the area of construction and operation of intake and discharge channels
Landscape / Visual Impact /Topography	The geo-morphological land forms and terrain at the ROW transmission lines and surrounding areas of the plant.
Biological Environment	
Flora	Plant species occurring in the areas in which the construction and operational activities would occur.
Birds	Birds that rely on the area as a habitat and/or food source.

RECEPTOR	**COMMENT**
Reptiles	Reptiles (e.g. snakes) that occur in the environment in which construction and operational activities are to occur.
Mammals	Mammals that occur in the environments in which construction activities are proposed to occur.
Socio-economic Environment	
Population within the Vicinity of Activity and close proximity to the project area as well as the country in general	The population (people) that live or generate livelihood in the areas in which construction and operational activities are to occur. As well as people who would be engaged in economic activities or employed directly by the project
Land and Sea Uses	Existing uses such asfarming of land areas which the construction and operational activities are to occur and fishing within the seawater where facility would be installed and arranged.
Utilities and infrastructure	The utilities (e.g. power supply, water, sewage services) and infrastructure (e.g. roads, schools, hospitals, community halls provided by government for use by the local community) of areas in which the construction activities are proposed to occur.
Transport	The road and air transport systems (i.e. physical network and vehicles that use them) that may be used during the project development phase.
Oil and Gas Infrastructure	Existing oil/gas infrastructure in the areas in which the construction and operational activities are proposed to occur.
Archaeology / Cultural Heritage	Archaeological sites, artefacts, secred grooves that have cultural significance.
Other	
Liability / Reputation	The legal liability and the reputation of Volta River Authority and Shenzhen Energy Group, as well as CCCC-FHDI Engineering, Premier Resource Consulting, ESL Consulting and Envaserv Research Consult responsible for project Design and Environmental Management

8 MITIGATION MEASURES

This chapter presents the description of the proposed mitigation measures from the pre-construction, construction, operational and decommissioning activities; and outlines the details of the specific mitigation options and considerations for preventing, minimizing or eliminating the effects of significant negative impacts against the identified significant impacts, defined in terms of costs, manpower, equipment and technology needs.

The mitigation measures have been developed to address the residual impact remaining after design mitigation measure and the possible cumulative impact.

The impact is characterized by its magnitude and the likelihood of occurrence. Likelihood is estimated on the basis of experience and/or evidence that such an outcome has previously occurred given the set conditions. It is defined as a measure of the degree to which the unplanned event is expected to occur; and not the degree to which an impact or effect is expected to occur as a result of the unplanned event (Uncertainty)

Unlikely	The event is unlikely but may occur at some time during normal operating conditions.
Possible	The event is likely to occur at some time during normal operating conditions
Likely	The event will occur during normal operating conditions (i.e. it is essentially inevitable)

8.1 Constructional Phase

8.1.1 Control of Emissions

Vehicular emissions and dust generated from various construction activities during site preparation, construction and transportation of materials would be controlled using the most appropriate measure for each scenario. Dust suppressants such as water spraying would be employed to control dust emissions during site preparation and excavation. Tarpaulin covers would be provided for all aggregate materials and sand being transported from quarries and related sites to project site. Trucks carrying construction materials would be limited to a speed of 40km/h. Good operating and maintenance practices would be adopted to maintain the vehicular machines and related equipment in good and efficient operating condition to ensure minimal emissions.

8.1.2 Control of Road Damage and Vehicular Traffic

Materials would be delivered to the site by trucks using the access road. In general, all major equipment will be supplied from offshore through the material handling terminal and transferred to the site.

However, construction materials would be delivered to the site by road. Maximum tonnage requirements for heavy trucks and vehicles would be strictly adhered to in order to prevent road damage during their transport to site. Maximum speed limits would be observed to ensure safety and fuel efficiency.

Nonetheless the traffic on the Accra – Cape Coast high way is not envisaged to be significantly high during construction especially since majority of the material will be generated on site, hence any change in traffic composition would make it necessary to put in measures to mitigate such impacts. Appropriate road signs would be used to alert road users to the potential dangers posed by trucks driving on the main road; turning, entering and crossing the main road as well. Long vehicles transporting plant parts would be clearly labelled to adequately warn other road users. Transportation of heavy equipment would be restricted to daytime. Only vehicles that are road worthy would be used for the project so as to avoid any breakdowns and unnecessary obstructions and potential accidents on the roads.

8.1.3 Disposal of Excavated Material

It is not anticipated that there would be any large quantity of excavated material for disposal as the project is structured to adopt considerable cutting and filling to balance material demand. Consequently, the fill requirements on site would use most of the excavated material.

8.1.4 Noise and Vibration Control

The noise and vibration related impacts are predicted could be moderately significant. Noise and vibration generated from initial drilling and blasting works, operation of machinery and vehicular movement would be significantly controlled to minimize the level and nuisance through the adoption of appropriate techniques.

Generally, the techniques are identified to include:

a) Ensuring properly maintained operating machines and equipment.

b) Appropriately controlled drilling and blasting schedules and timing to ensure minimal impact. Drilling and blasting after 6:00pm would be strictly prohibited.

c) Blasting and construction activities are planned and arranged remotely from the residential receptors. The noise and vibration sources would be set within the southern area along the shore and at considerable distances from the boundaries of the northern and eastern ends where largely the communities are situated.

d) Ensuring local land use zoning controls are appropriately enforced.

e) Use of acoustic enclosures based on the isolation effect to envelop construction sites and construction machinery and equipment.

f) Developing noise barriers where appropriate to limit ambient noise during construction period.

The other measures to minimize noise would include:

a) *Earth Moving Plant*: The use of effective exhaust sound reduction equipment and ensuring manufacturers enclosure panels are closed at all time. Alternative super-silenced plant may be available;

b) *Compressors and Generators:* The use of effective sound reduction equipment, dampening of the metal body casing and ensuring manufacturers enclosure panels are closed at all time. Screening may be erected and some equipment may be placed in a ventilated acoustic enclosure;

c) Breakers and Drills: The use of mufflers, sound reduction equipment, fixing any airline leaks, use dampened bits, screening and enclosures; and

d) Cement Mixing, Materials Handling and Batching Plant: The use of effective engine sound reduction equipment, enclosing the engine, ensuring aggregate does not fall from an excessive height and not dropping materials from excessive heights.

Ear protectors will be provided to ensure the health and safety of on-site construction staff to control exposure to higher noise sources.

Emergency mitigation measures would include informing the EPA and the community of unusual activities of significant potential noise and vibration generation or significant changes to the construction programme that may result in increased noise levels and time of noise nuisance. Particularly, construction works outside the premises of the project (external) will be carried out only in exceptional instances and with prior consent of the local authorities.

In addition, the Environmental team would be particular about noise and vibration concerns and complaints especially from neighbouring residents.

In general schedule of construction works that a likely to generate significant would remain within the time period of 7 am to 6 pm.

8.1.5 Occupational Health and Safety

The potential dangerous exposures to workers are identified to include electrocution, exposure to electromagnetic radiation, hearing impairment caused by exposure to continuous high levels of noise, dust inhalation leading to respiratory problem and accidents from falls.

The mitigate measures would demand contractors to meet specific standards, which would be stipulated conditions under the contract including:

Providing protective clothing suitable for construction site such as gloves, protective boots, helmets, earmuffs, overalls nose masks and goggles.

Workers would be required to wear the appropriate clothing when at work

Appropriate equipment like scaffolding would be provided

Well-equipped on-site first aid facility would be provided and an adequately trained staff would be put in charge to offer first aid service.

Wounded workers would be taken to the nearest hospital for treatment.

Health and safety awareness training would be provided for all staff to help them understand the need for safety procedures.

Occupational health and safety performance would be evaluated against internationally published exposure guidelines including Indicative Occupational Exposure Limit Values published by European Union member states.

Projects would ensure prevention or minimal accidents among all project workers both directly and indirectly employed; particularly, accidents causing disabilities and fatalities would be eliminated.

The working environment would also be monitored through all the phases of project for relevant occupational hazards. An Occupational Health and Safety Monitoring Programme would be appropriately developed and carried out in the project.

In addition, the project would establish records of occupational accidents and diseases and dangerous occurrences and accidents.

8.1.6 Cultural, Historical and Traditional Heritage

The communities are privileged with varieties of historical resources, cultural and traditional heritage forming the conceptions, beliefs, reverence, obedience and faith of the people, which also contribute to the socio-cultural and economic well-being of the people.

The communities have varieties of historical resources, cultural and traditional heritage forming the conceptions, beliefs, reverence, obedience and faith of the people, which also contribute to the socio-cultural and economic well-being of the people.

A key mitigation approach would be engaging the various stakeholders in extensive consultations in determining suitable options for common interest so as not to disturb the harmony and consolation of the settlers. The consultations would consider the following mitigation interventions:

- The possibilities of removal or relocation of the deities where appropriate and where not appropriate the location would be well demarcated and protected with suitable fencing to preserve the historical, cultural and traditional heritage and significance.

- Creating the necessary understanding of the importance of the project and its usefulness to national interest to the people and the need to find suitable common interest to preserve cultural influence and beliefs of the settlers.

- Providing adequate compensation to the various stakeholders not necessarily to influence their decision but also to ensure adequate funding for relocation and preservation of cultural and traditional values.

- Promoting cultural and traditional identities of the people through preserving colours, texture and symbols of the people, by ensuring that these are conscientiously exposed to the people at all times especially at the heritage sites and project sites to arouse sense of belonging. For example, varieties of colours dominate ritual sites, which are identified to include Abotreh rock denoting white as its main color; the Esiwodo point of intersection has red color; the Odaabiriadze Grove has red and black as the principal colours and the water path, Nana Atsiribura uses white for rituals.

- Memorials, Plaques and Epitaphs should be erected in memory of the sites when they have fully been relocated and short historical background engraved on the plaques.

8.1.7 Socio-economic

Potential retrenchment of workers especially during the switch from the construction phase to the operation phase of the project would lead to job loss and consequent income loss. It would be expected of the contractor to make adequate provision for appropriate severance packages and redundancy programme to effectively mitigate the associated impact.

8.2 Operational Phase

8.2.1 Air Quality

Super-critical coal-fired power plant potentially would generate significant emission pollutants from the combustion of coal that could affect the ambient air quality during its operation. The principal receptors are the residents of the communities within the project area of Influence.

Based on the plant design, the various mitigation measures to control flue gas emission include:

- Supercritical pulverized coal-fired boiler technology
- Choice of coal fuel giving preference to high-heat-content and low-sulfur coal
- Electro-static Precipitator (ESP) for removal of dust in flue gas
- Seawater Flue Gas Desulfurization (FGD) for removal of SOx in the flue gas
- Low NOx burners
- Selective Catalytic Reduction (SCR) for removal of NOx in the flue gas
- Stack configuration with a height of 180 metres

Mitigation measures of the coal dust include:

- Enclosed coal stockyard will prevent flying of fugitive coal dust
- Water spray system will be installed in the coal stockyard for dust suppression
- Enclosed belt conveyor system
- Skirtboard will be installed at each loading points in all transfer towers. The part between head hopper (above the conveyor and below the skirtboard) will be totally enclosed.
- Pulse fabric dust collectors will be provided at the main fugitive dust points such as coal transfer tower and bunker bay.
- Water cleaning system will be installed in transfer towers, crusher tower, and bunker bay.
- Sealing Air Fan would be installed to prevent the fugitive dust from the coal mill.

On the basis of the air quality modelling study the residual impact of air pollutants on the quality of ambient air including SO_2, NOx and PM is considered low and the likely severity would be minor.

Nonetheless, five continuous emission monitoring station would be established at various locations including the communities based on the air quality modelling results to effectively monitor the ground level concentrations and the overall environmental performance of the power plant on air quality.

8.2.2 Noise Control

High level noise or nuisance would be controlled by a number of measures considered from the design stage through operational phase. Greater focus would be on minimizing the exposure of workers to high level noise as the residual noise exposure to the neighbouring community receptors is significantly low.

Generally, the plant design has set the acoustic performance specifications for the plant at the various units to ensure that plant, machinery and equipment having higher residual noise levels appropriately designated and arranged to restrict access. The building and plant design also take into consideration the attenuation of internally generated noise to reduce the output noise to acceptable levels.

The selection of plant, machinery and equipment has taken into account the noise levels of the individual machines and equipment to ensure that the overall residual noise level is minimal.

Further to the various mitigation measures, the worker would be compelled to use personal protective equipment to minimize or eliminate any high residual noise.

Additional mitigation measure to minimize impact of higher residual noise is ensuring the establishment of work programme that limit the duration of workers' exposure or attenuation to such higher residual noise.

Boiler units including the milling and crushing machines, steam turbines and related steam systems and equipment and piping, and pumping stations, related equipment and piping are provided with adequate noise control measures such as acoustic insulation and enclosures, inlet and exhaust silencers, duct mounted attenuators, acoustic louvers and vibration isolation systems would be employed. The noise attenuation techniques would be designed to reduce noise across the frequency spectrum, at both low and high frequencies.

The noise levels within the boiler area, turbine hall and related designated work areas and pumping stations shall not exceed the upper noise levels of 84 dB.

The other primary sources of noise mainly the external facilities including ESP, FGD, hydraulic equipment, compressors, handling equipment, mechanical draft cooling tower and related equipment, pipe works, transformers and transmission network would be arranged to minimize noise levels. Sound attenuation techniques such as insulation, enclosures, low speed fans and low noise trims would be used where necessary in order to reduce the ambient noise to the acceptable levels.

Additional requirements set to validate the modelled plant noise levels in the high noise designated areas during operation to evaluate empirical noise generation of the plant. Nonetheless, the plant will guarantee meeting the Ghanaian and World Bank operational noise criteria. Monitoring of the noise impact during plant operation would be key to managing the noise impact of the plant at the identified noise sensitive receptors.

Workers and visitors would be protected with ear-protectors when necessary to ensure minimal impact. Signage would be clearly provided in English and Chinese languages to ensure appropriate and adequate warning to workers and visitors at all requisite areas with noise levels close to the permissible limits.

Additionally, the Project would ensure minimum of 200 metres buffer zone beyond the fence wall around the plant site. Furthermore, the project would ensure consistent monitoring of noise at designated locations where critical receptors are exposed to ensure that noise levels remain within the appropriate permissible national environmental quality guideline at all times.

8.2.3 Waste water

All waste water originating from the plant during operation will be treated fully using the industrial sewage treatment equipment as required to meet specified effluent quality criteria. All waste streams would be combined to a single point discharge and monitored prior to final discharge.

Site drainage system is set closed conduit and centralized discharge sloping to the road of the site, draining out of the plant site and discharged into the sea. All sloping areas are covered with grass and stone pitching especially on both bottom side of the site access road to protect the shoulder.

8.2.4 Solid Waste

Solid waste generation would be controlled by deploying resource use efficient techniques and material recycle and reuse approaches to prevent and minimize the impact of disposal. Particularly, coal ash would be reused as input component to cement in the production of cement blocks and concrete products.

8.2.5 Soil

Soil erosion would be controlled by ensuring effective drainage of storm water from the site and setting suitable greening scheme to prevent or limit soil exposed areas especially along slopes. Greening involving grass and trees would be planted on both sides of the road and designated areas around the plant sites to cover land area estimated to 54,980 m^2at a rate of 20%of the plant area.

Also soil contamination would be controlled by ensuring efficient scheme is developed to facilitate spill prevention and emergency management response.

8.2.6 Occupational Health and Safety

Primarily, occupational hazards and risks are controls by deploying design measures to minimize residual impact to workers and where necessary workers would deploy personal protective equipment to control higher residual impact.

8.2.7 Community Health and Safety

The potential public health risks and insecurity resulting from project implementation and subsequent increased community population and attendant demand on community health and educational facilities would be addressed as following:

- Improved public health facilities and management
- Increased public health education and sensitization on potential health risks including emotional stress and sexually transmitted diseases (STD).
- Traffic and transportation management plan
- Controlled public access to construction sites and restricted areas
- Public security management plan involving improvement of the Police Post and operations.
- Institution of grievance mechanism to address emerging concerns
- Public Health and Safety Management Plan

Table 8-1 Mitigation Measures of Construction Phase

Environmental Parameter	**Potential Impact**	**Significance / Occurrence**	**Proposed Mitigation**	**Residual Impact**	**Residual Severity**
Air	Degradation of ambient air quality and attendant effect on workers and neighbouring communities	Moderate and very likely	Construction Contractor to implement dust suppression techniques on construction surfaces Provision of tarpaulins for trucks delivering sand and gravels to the site. Regular maintenance of construction vehicles and heavy machinery and equipment. The exhaust emissions of vehicles and heavy machinery and equipment would be monitored and controlled.	Minor	Minor and likely
Noise	Nuisance to workers and residents of neighbouring communities	Moderate and likely	Regular maintenance of machinery and ensuring noise from the machinery is low Working areas on the project site would be fenced Working periods would be controlled and would be between 7:00 am to 6:00 pm	Moderate and likely	Minor

Environmental Parameter	**Potential Impact**	**Significance / Occurrence**	**Proposed Mitigation**	**Residual Impact**	**Residual Severity**
Traffic	Congestion and accidents	Moderate and likely	Trucks would be appropriately marked with reflectors and warning signs indicating long vehicle and speed limits to caution other drivers	Low impact is expected	Minor and unlikely
Water Resources	• Contamination of groundwater and surface water. • Damage to aquatic environment and fishery activities	Moderate and likely	Treatment of sewage. Construction Contractor would adopt strict fuelling and spill control procedures. Where practicable, all fuel storage areas would be secured. Develop spill response and management plan and measures.	Minor and likely	Minor
Land	• Indiscriminate Waste disposal • Contamination of soil • Soil erosion • Landscape visual impacts	Moderate and likely	• Development of a Waste Management Plan. • Waste Management Training of construction personnel. • Secure fuel storage areas and develop strict fueling and spill control procedures • Develop greening and landscape management scheme	Minor and likely	Minor
Ecology	Disturbance to the terrestrial ecosystem	Moderate and likely	Control of construction activities ensuring mammal have ample time to migrate.	Minor and likely	Minor

Environmental Parameter	**Potential Impact**	**Significance / Occurrence**	**Proposed Mitigation**	**Residual Impact**	**Residual Severity**
	Disturbance to the marine ecosystem and mammals	Moderate and likely			
Occupational Health and Safety	• Health risks and possibilities of respiratory problems, hearing impairment • Potential accidents including electrocution fall etc. resulting in injuries and fatalities	Moderate and unlikely	• Health and Safety education and awareness • Provision and appropriate use of personal protective equipment • Use of suitable clothing • Emergency response plan • Monitoring and reporting scheme established	Minor and unlikely	Minor
Socio-economic	• Increased economic activities (trading) and competition for local economic operators • Decent jobs for local inhabitants (unskilled labour) and income opportunities • Increased local population • Loss of farmland and reduced farming output	Moderate and likely	• Stakeholders engagement and monitoring scheme established • Appropriate compensation of farmers for loss of land and crops • Adequate education of the farmers	Moderate and likely	Moderate

Environmental Parameter	**Potential Impact**	**Significance / Occurrence**	**Proposed Mitigation**	**Residual Impact**	**Residual Severity**
Community Health and Safety	• Potential health risk due to degraded air quality, noise and vibration, visual impact and resulting emotional stress. • Potential increase in traffic accidents • Increased public insecurity • Increased community population and attendant demand on community health and educational facilities	Moderate and likely	• Improved public health facilities and management • Increased public education and sensitization • Traffic and transportation management plan • Controlled public access to construction sites and restricted areas • Public security management plan (improving Police Post) • Institution of grievance mechanism • Public Health and Safety Management Plan	Minor and unlikely	Minor

Table 8-2 Mitigation Measures of Operational Phase

Environmental Parameter	Potential Impact	Significance / Occurrence	Proposed Mitigation	Residual Impact	Residual Severity
Air	Deterioration of air quality and attendant effect on human health. According to the emission dispersion modelling study the ground leve concentration (GLC) of the emission pollutants, SO_2, NOx and PM, are all below the respective EPA guideline values	Minor and unlikely	• Ensuring coal and ash handling and storage areas dust controls are fully functional and regularly monitored. • Ensuring stack emission controls are functional and regularly monitored. • Five continuous emission monitoring systems would be installed at designated locations. • Air quality measurement and audits would be done periodically to validate the level of concentration of emission pollutants.	Minor and unlikely	Minor
Noise	Nuisance to workers and residents of neighbouring communities	Moderate and unlikely	• Machinery and equipment would be provided with acoustic casing where appropriate. • Regular maintenance of	Minor and unlikely	Minor

Environmental Parameter	Potential Impact	Significance / Occurrence	Proposed Mitigation	Residual Impact	Residual Severity
			machinery and equipment and also ensuring noise from the machinery and equipment is low. • The designated high noise operational areas are appropriately shielded with noise absorbing fencing including shrubs and trees. • Workers and visitors would be provided with suitable PPEs		
Traffic	Increased traffic and related congestion and accidents	Minor and unlikely	• Staff movements would be coordinated and planned to promote group movement. • Use of mass transported where appropriate and restricting individual movements.	Minor and unlikely	Minor
Waste	Generation of waste and indiscriminate disposal and the associated impacts.	Minor and Unlikely	• Development of Waste Management and Monitoring Plan for the operational waste. • Ensuring appropriate waste management practices would be strictly enforced. • Adequate provisions would be made for effective and efficient waste management.	Minor and unlikely	Minor

Environmental Parameter	Potential Impact	Significance / Occurrence	Proposed Mitigation	Residual Impact	Residual Severity
Land	• Soil erosion and contamination and related land degradation. • Land use restriction • Land scape visual impact	Moderate and likely	• Greening scheme and soil protection using composite geomembrane for coal ash storage area • Periodic monitoring of soil quality • Develop landscape management plan and monitoring scheme.	Minor and unlikely	Minor
Sea water	Deterioration of seawater quality and temperature from discharge of process water Contamination of seawater by coal ash	Minor and unlikely	Continuous monitoring to ensure that the temperature of the mixing zone remains within the stipulated 2^0C above ambient seawater temperature and the quality of seawater also remains within acceptable standards.	Minor and unlikely	Minor
Ecology	• Disturbance to the terrestrial ecosystem • Disturbance to the marine ecosystem	Minor and unlikely	Continued periodic monitoring of the terrestrial and marine environment.	Minor and unlikely	Minor

Environmental Parameter	Potential Impact	Significance / Occurrence	Proposed Mitigation	Residual Impact	Residual Severity
Occupational Health and Safety	• Health risks and possibilities of respiratory problems, hearing impairment • Potential accidents including electrocution, irradiation, fall etc. resulting in injuries and fatalities	Moderate and likely	• Health and Safety education and awareness • Provision and appropriate use of personal protective equipment • Use of suitable clothing • Emergency response plan • Monitoring and reporting scheme established	Minor and unlikely	Minor
Socio-economic	• Increased economic activities (trading) and competition for local economic operators • Decent jobs for local inhabitants (unskilled labour) and income opportunities • Increased local population • Loss of access to fishing area and disturbance to fishing operation. • Increased fish catch due to additional illumination and increased sea depth • Loss of farmland and restricted farming practices	Moderate and likely	• Stakeholders engagement and monitoring scheme established • Restricted sea areas would be clearly demarcated • New fishing route established and alternate fish landing practices encouraged • Appropriate compensation of fishermen and farmers • Adequate education of the fishermen • Two suitable landing sites created and provided with appropriate facilities	Moderate and likely	Moderate

Environmental Parameter	Potential Impact	Significance / Occurrence	Proposed Mitigation	Residual Impact	Residual Severity
	• Improved fish landing site and handling				
Community Health and Safety	• Potential health risk due to degraded air quality, visual impact and resulting emotional stress. • emotional stress • Potential increase in traffic accidents • Increased public insecurity • Increased community population and attendant demand on community health and educational facilities	Moderate and likely	• Improved public health facilities and management • Increased public health education and sensitization including STD. • Traffic and transportation management plan • Controlled public access to construction sites and restricted areas • Public security management plan (improving Police Post) • Institution of grievance mechanism • Public Health and Safety Management Plan	Minor and unlikely	Minor

9 MONITORING PLAN

The chapter outlines the monitoring measures and activities envisaged for the evaluating the significance of deviations of the projected environmental performance from established baseline conditions and the guideline requirements. It also specifies the main areas and parameters to be monitored during the various phases of the project implementation. Furthermore, the section outlines the training requirements of the relevant staff.

The Management of the Project would be committed to undertaking continuous monitoring of significant impacts identified, which would form part of the managerial tool for prompt remedial action taken to correct unforeseen deviations in the effectiveness of mitigation measures. The monitoring results would offer the Project an understanding of the overall actual impacts of the Project.

9.1 Constructional Phase Monitoring Activities

The key monitoring areas during the project construction phase would include Air Quality, Noise and Resource Use Efficiency.

1. Air Quality

   The principal air pollutants would include Particulate Matter especially dust, Sulphur dioxide, oxides of Nitrogen, and Carbon Monoxide. Monitoring activities in this respect would focus on ambient air quality at designated points including the two adjoining settlements, Kontankore and Ekumfi Aboano. Ambient air quality would be monitored regularly on a monthly basis.

2. Noise

   Noise level monitoring would concentrate on on-site monitoring; however, this would also cover ambient noise levels in the adjoining communities. Regular monthly monitoring would be conducted to determine the actual impact on both workers and inhabitants of the near-by communities.

3. Resource Use Efficiency

   Consumption of key resources would be determined regularly on the monthly basis to establish the consumption trends and efficiency.

9.2 Operational Phase Monitoring Activities

9.2.1 Air Quality

Air pollutants such as Suspended Particulate Matter, Sulphur dioxide, oxides of Nitrogen and Carbon monoxide shall be determined at various locations within the plant area and the communities. Five continuous monitoring stations would be set up.

Air pollution control monitoring shall be conducted to involve:

a) Stack emission monitoring and emission compliance validation.

b) Validation of the completeness of control equipment installed for minimizing the emission of pollutant from stack.

c) Inspection of in-plant control measures to contain fugitive emissions.

d) Verification of the adequacy and performance of facilities provided to monitor stack emissions and ground level concentration of air pollutants.

9.2.2 Effluent

Effluent from the plant would be monitored after treatment before discharge to ensure compliance to EPA Standards and IFC guideline. Effluent sample analysis shall determine the following parameters:

• pH	Sulphide (mg/l)
• Oil and Grease (mg/l)	Temperature increase (°C)
• Colour (TCU)	Total Dissolved solids (mg/l
• Chemical Oxygen Demand mg/l)	Turbidity (N.T.U)
• Biological Oxygen Demand (BOD_5) (mg/l)	Total Suspended Solids (mg/l)
• Lead (mg/l)	Nitrate (mg/l)
• Arsenic	Mercury
• Conductivity (uS/cm)	Total Coli forms (MPN/100ml)

Furthermore, the quality of the seawater where the intake facility and discharge facility are situated would be monitored in relation to the above parameters and in particular heavy metal contamination. Additional, heavy metal contamination in fishes within the area of influence would also be monitored periodically. During the first 3 years of operation the heavy metal contamination would be monitored bi-annually. Subsequently, the monitoring would be annually.

Waste water would meet the following quality guidelines (shown in ***Table 9-1***) before discharges into the sea.

Table 9-1 Sector Specific Effluent Guideline for Discharge into Natural Water Bodies

No.	Parameter	Sector: Thermal Power Plant
1	pH	6-9
2	BOD(mg/l)	50
3	Oil and Grease (mg/l)	5
5	Total Suspended Solids (mg/l)	50
6	Total Phosphorous (mg/l)	2.0
7	Temperature increase	<3°C above ambient
8	Colour (TCU)	200
9	COD (mg/l)	250
10	Sulphide (mg/l)	1.5
11	Turbidity (NTU)	75
12	Lead (mg/l)	0.1
13	Nitrate (mg/l)	50

9.2.3 In-take and Discharge Cooling Water

The in-take and discharge cooling seawater quality and temperature would be continuously monitored to conform to the required temperature before discharge into the sea. Furthermore, the marine environment within the mixing zone and beyond would be monitored to ensure any potential impact would be detected early prevent any effects to marine habitat. Also heavy metal contamination of the seawater and fishes would be monitored against the baseline data established. The heavy metal parameters would include

The monitoring of the marine environment would be conducted monthly.

9.2.4 Noise Monitoring

Higher point sources of noise generation would be identified and monitored consistently. Noise level at various locations within the plant and outside plant area within the nearby communities would be monitored consistently and on monthly basis. Any unforeseen excessive noise from any machinery or equipment would be identified and recommended for immediate attention to resolve the situation.

9.2.5 Soil and Groundwater Quality Monitoring

Soil contamination is likely and therefore monitoring soil quality and especially for heavy metal contaminants.

A seasonal water body, Atsiribura stream, is identified within the Aboano Community, due to the seasonal nature of the water which comes up during the raining season, the monitoring programme would be structured to follow the seasonal pattern. However, an initial water quality analysis would be conducted to establish the baseline and would be subsequently monitored according to the seasonal appearance.

9.2.6 Solid Waste Monitoring

Handling and management of coal ash would be monitored closely through daily inspections of the coal handling system. Furthermore, the heavy metal pollution of ground and underground water would be monitored through chemical analysis of soil samples and underground water samples quality based on carefully selected sampling points and developed sampling wells around the ash yard.

Additionally, daily inspection of waste bins would be conducted and consistently monitored to evaluate waste generation and resource use efficiency improvement. Daily collection of solid waste would be contracted to an approved waste collector. Record would be kept on the quantity of waste generated on daily basis.

9.2.7 Occupational Health and Safety Monitoring

The use of personal protective equipment is very important aspect of mitigation, especially against dust, noise, excessive heat and electrocution. Therefore, the availability and use of personal protective equipment would be continuously monitored throughout the various phases of the project. All damaged and defective protective equipment would be promptly replaced. Employees who refuse to use the protective equipment would be sanctioned in line with agreed sanctions.

Health and safety training programmes and environmental awareness creation programmes would be organised annually for all workers both the Ghanaian and Chinese worker.

9.2.8 Resource Usage Monitoring

Documentation and records on the use of resources including water, chemicals, fuel and lubricants would be established to assess the total resource use, which would be reviewed monthly to evaluate overall performance and resource efficiency.

9.3 Reporting

In line with the Monthly Monitoring and Reporting requirements, the Project would establish monthly reporting scheme and submit accordingly as required by EPA to meet national compliance requirements and fitting into international practices.

An annual report which comprises all monthly returns and assessments compliance levels and other environmental issues encountered during the year would be presented to EPA annually.

10 PROVISIONAL ENVIRONMENTAL MANAGEMENT PLAN

The Provisional Environmental Management Plan is prepared as part of the ESIA and outlines the environmental management processes and emergency response planning. The provisional EMP, which reflects the management structure and commitment of the project to safeguard the environmental quality and safety integrity, summarizes the roles and responsibilities, organizational requirements, implementation actions, monitoring plan and specific mitigation actions necessary to meet the projected environmental management obligations.

10.1 Introduction

The environmental and social impact assessment (ESIA) has involved prediction of the potential impacts and mitigation measures to form basis for informed environmental decision-making process on the proposed development and operation of the 2X350MW Supercritical Coal-fired Power Plant. The Provisional EMP is therefore relevant to outline necessary environmental management planning and commitment to the prevention and minimization of any potential residual impacts to acceptable levels in environmental quality, health and safety standards and where necessary compensation payment to alleviate potential impact.

The usefulness of ESIA by way of its potential benefits and contribution to sound development is realised, when the ESIA is translated into Environmental Management Plan (EMP) and implemented, during the development and operation of the project.

The processes and actions outlined in the provisional EMP are based on the information established in relation to the baseline conditions of the project area and the projected impacts and mitigations. The management planning would cover project site preparation and construction phase, operational and decommissioning phases of the project and permit verification of predicted impact, adequacy and effectiveness of mitigations, monitoring relevant contingency measures and introduction of additional corrective measures where necessary. The provisional EMP would therefore serve the basis of precursor to the Actual EMP developed during the project implementation phase.

The provisional EMP has been prepared also taking into consideration the international standards and guidelines including the performance standards of IFC and Equator Principles.

The relevant sections of the Provisional EMP would comprise the following:

g) Mitigation plan (on-site and off-site, construction and operation)
h) Monitoring plan (on-site and off-site, construction and operation)
i) Emergency response plan
j) Training and awareness creation programmes
k) Documentation and reporting
l) Financial requirements for effective plan implementation.

10.2Objectives

The principal objective of the Provisional Environmental Management Plan is to establish an Environmental Management System (EMS) that clearly stated steps and actions necessary to ensure that mitigation measures are conducted effectively and efficiently to minimize the impacts of the power plant and affiliated facilities. Also thorough monitoring of results and identification of ineffective mitigation measures may be realized.

The EMS is particularly developed to include the organizational structure, planning and resources for developing, implementing and maintaining the project corporate policy for environmental protection.

The primary goal is to increase compliance and reduce waste. For this project waste reduction begins at the design phase through pollution prevention and waste minimization; recognizing waste reduction beyond compliance with continued improvement of reducing environmental impact in line with VRA and SEC environmental policies.

The EMS would therefore provide systematic way of managing corporate environmental affairs and consistent way of addressing environmental concerns through allocation of resources, assignment of responsibility and evaluation of processes.

10.3Roles and Responsibilities of the Project

The measures necessary to ensure effective and efficient implementation of the Provisional ESMP include establishing Project Environmental and Social Management Unit as a part of the Project Management Team.

The Project Environmental and Social Management Unit shall be duly constituted and shall be responsible for the various aspects of the environmental and social management of the project and shall also provide support where needed in communication and community consultation.

Activities planned within the framework of the project include the following:

a) Coordinate data collection and analysis and make appropriate recommendations to the project management team on environmental and social issues.

b) Develop activities to coordinate environmental and social management activities of the project.

c) Promote resource efficiency and cleaner production initiatives.

d) Coordinate the project activities to comply with the requisite regulatory requirements.

e) Implement the Provisional Environmental Management Plan developed

The Provision Environmental and Social Management Plan would incorporate an Environmental and Social Management System (ESMS), which will be enforced to ensure compliance to all relevant environmental quality guideline. The ESMS will integrate various management systems and plans including:

a) Compliance Management Plan
b) Waste Management Plan
c) Resource Efficient Management Plan
d) Health and Safety Management Plan
e) Air Quality Management Plan
f) Emergency Preparedness and Response Plan

The table below provides further information on the environmental action plan to be implemented. Budgetary provisions are made for all activities earmarked for implementation to facilitate meeting the required objectives of the Provisional ESMP.

Table 10-1 Summary of the Environmental Action Plans to be Implemented by the Project

ACTION	TARGET	TIMELINE	BUDGET (GH¢)	RESPONSIBILITY	RECORDS
1. Compliance Management Plan: Meetings goals and obligations Under Environmental Legislation					
Develop scope of work for the implementation of the action plan	Scope of work to be used by EMC to implement the action plan	March 2017	-	Project environmental and social management unit	Project Management team
Establish Environmental Management Committee (EMC)	Project Management Team to endorse establishment of EMCs and related activities	May 2017	-	Project environmental and social management unit	Letter for official recognition of the EMC by Management & records of EMC meetings
Sensitize, educate and train staff on environment, health and safety (EHS) responsibilities at workplace	All staff participate in training in specific areas of environment, health and safety,	Annually	15,000.00	Management, EMC and Project Environmental Consultant	Invoices, training materials, attendance list of participants
Promote behavioural changes among staff to reduce significantly resource consumption and increase recycling and reuse e.g. regular briefings and programmes	Staff engage actively in effective waste management	Daily, weekly	N/A	EMC, supervisors & managers	Utility bills & records, & training
Collect and analyze feedback from staff and management on resource efficiency related programmes and projects	Monitor the progress of the EMC towards achieving its goals set out in the Provisional ESMP	Monthly	N/A	EMC, Supervisors & Managers	Records or minutes of EMC meetings

ACTION	TARGET	TIMELINE	BUDGET (GH¢)	RESPONSIBILITY	RECORDS
Environmental Monitoring Reporting and permit renewal	Monitor environmental quality and report to both Management and Regulatory Agencies	Quarterly, annual	20,000.00	EMC, Consultants & Supervisors	Quarterly reports, annual environmental reports, EMP report preparation
Train staff to carry out daily and weekly checks on environmental compliance	Form environmentally-responsible employees selected from different departments to help promote the environmental and recycling efforts of the EMC and the Project	To be determine d	5000.00	EMC & Consultants	Records of training, records of staff attendance of training programmes
Regular reporting and collaboration with regulatory Agencies	Ensure that all compliance is achieved for all regulatory Agencies	Regularly	10,000.00	EMC/Consultant	Minutes of meetings, attendance sheet, reports prepared and submitted
Report regularly to Senior Management and staff on actions undertaken against targets and on future areas of focus for the next period	Communicate environmental performance to staff and directors	Quarterly	-	EMC	Environmental Performance reports,
2. Resource Efficient Management Plan: Energy, Raw Materials And Water Efficiency					
Conduct Energy Audit	Identify areas where energy savings can be	Quarterly	16,000.00	Consultants, EMC, Production	Maintenance reports, purchase

ACTION	TARGET	TIMELINE	BUDGET (GH¢)	RESPONSIBILITY	RECORDS
	made.			and Maintenance Departments	invoices
Conduct energy audit reviewing performance of machines, electrical equipment, and carry out and resource efficient intervention .	Reduce energy consumption by 30%	2017	65,000.00	Consultants, EMC, Production & Maintenance Departments	Invoices &Receipts
Conduct water audit (design water flow chart, compile and analyse reliable data on water use & consumption pattern)	Identify areas where water savings can be made	Quarterly	10,000.00	Consultants, EMC, Production & Maintenance Departments	Water Audit Reports, water flow charts, invoices & receipts
Carry out maintenance on tanks, pipes and other equipment through which water and steam passes, install water meters, valves, lagging of steam pipes	Ensure water savings by 30%	May 2017	30,000.00	Consultants, EMC, Production & Maintenance Departments	Installed meters, valves, regular reports
Conduct raw material consumption audit	Identify areas in which raw materials are wasted	Quarterly	10,000.00	Consultants, EMC, Production & Maintenance Department	Report on identified areas of savings
Implement any other recommendations from water audit, Install accurate weighing and other equipment to minimize spillage and waste, minimize human contact with raw materials that will lead to	Minimise raw material waste by 30%	May, 2017	40,000.00	Consultants, EMC, Production & Maintenance Department	Reduced waste in raw materials, receipts & invoices

ACTION	TARGET	TIMELINE	BUDGET (GH¢)	RESPONSIBILITY	RECORDS
spillage					
3. Waste Management Plan: Waste Generation, Prevention & Control					
Carry out a comprehensive waste audit	Identify ways by which waste can be minimized and make recommendations to accordingly	Quarterly	5,000.00	Consultant, EMC, Production & Maintenance Departments	Waste audit report
Construction of band wall around workshop environment and clean-up of environment where waste oil is generated	Ensure a clean environment within the workshop area and containment of waste oil spillage within the workshop environment	December, 2017	15,000.00	EMC	Engage a contractor/maso n for construction
Provision of oil cleaning materials and equipment	Ensure clean and hygienic environment after oil spillage	Regularly	10,000.00	Cleaning staff and external consultant services	Reports on cleaning submitted
Implement a waste collection recycling programme	Provide facilities for waste collection and segregation	June, 2018	5,000.00	Consultant, EMC, Production and Maintenance Department	Waste collection bins & other facilities
Conduct feasibility study on alternative waste management options	Promote recycle, reuse and minimization of waste	December, 2017	5,000.00	Consultant, EMC & EPA	Feasibility study report
Promote the procurement of biodegradable material	Minimize the use of non-biodegradable raw materials	December 2017	N/A	EMC, Procurement, Maintenance & Production Dept	Proforma invoices, receipts
Enforce the use of personal	Ensure that workers are	Daily	10,000.00	EMC	Purchase of

ACTION	TARGET	TIMELINE	BUDGET (GH¢)	RESPONSIBILITY	RECORDS
protective equipment	not unnecessarily exposed to health hazards				PPEs, receipts and invoices
Perform maintenance on equipment	Limit noise levels and vibrations	Daily/weekly	38,000.00	EMC, Senior Management, Production & Maintenance Department	Replacement of equipment part, invoices and receipts
Invest in energy efficient and low levels of noise and radiation generation equipment	Ensure that noise and other regulatory requirements have been met	Daily/weekly	40,000.00	Consultant, EMC, Senior Management, Production &Maintenance Department	Procurement contracts, invoices & receipts, replaced parts
4. Fire Risk Management Plan					
Ensure warning signals are functional and broken down alarm systems are replaced	Provide protection and minimize damage in case of severe hazards	Quarterly	10,000.00	EMC, Maintenance Department	Assessment report, invoices & receipts
Ensure regular fire safety equipment maintenance and alarm systems	Replace fire extinguishers, faulty fire alarm systems etc	Quarterly	5,000.00	EMC,	Reports submitted to senior management, functioning fire safety equipment and alarm systems
Prepare and review emergency response plan and organize regular fire drills	Ensure workers are alert and aware on what they need to do during	Quarterly	10,000.00	EMC, Ghana National Fire Service	Signed attendance sheet,

ACTION	TARGET	TIMELINE	BUDGET (GH¢)	RESPONSIBILITY	RECORDS
	fire				
Ensure that relevant signage would be provided at visible locations within the plant	Provide direction to staff and visitors within the plant	May 2018	3,000.00	EMC, Maintenance Department	Invoices & receipts
Provide training in fire and occupational health and safety	Ensure staff know what to do in relation to safety, environmental and fire hazards	Twice per annum	8,000.00	Consultants, EMC, Senior Management	Attendance list, invoices & receipts
Ensure warehouse safety measures are put in place and adhered to	Eliminate the number of adverse factors that can cause extensive damage in the event of a fire outbreak (e.g. lack of free space between the stored goods and the ceiling/ inadequacies in storage space layout)	Quarterly	-	EMC, Store Management	Reports on warehouse management
TOTAL COST			428,000.00		

10.4 Health and Safety Action Plan

10.4.1 Noise and Hearing Loss

Noise levels will be measured regularly to ensure that these levels meet the EPA guidelines on noise. Monthly measurements will be taken and reported to the EPA where necessary. Moreover, measures would be in place to control both indoor and outdoor noise pollution.

There will measures to instill strict adherence to recommended maintenance schemes to optimize efficiency and performance of the machinery and equipment and also to promote reducing the noise levels in the installations.

Furthermore, it would be ensured that trees and plantations, especially surrounding buildings for the purpose of absorbing and blocking noise would be suitably set and managed to effectively meet its functional requirements.

Constant monitoring and training, however, are necessary to ensure that workers properly use the protective equipment. The introduction of compulsory audiometric testing for all employees exposed to excessive noise in the workplace (i.e. 85 dB or above) will likewise enable the Project to detect hearing impairment at an early stage so that intervention may quickly occur to prevent permanent noise-induced hearing loss.

10.4.2 Plant Lighting

The plant will be equipped with high-output energy-efficient light fixtures that are properly shielded to reduce glare. Appropriate actions will be taken to decrease the use of artificial lighting in areas where daylight provides sufficient illumination or where fewer light fittings combined with lower wattage are adequate.

In contrast, task lighting will be added to help plant workers perform their duties in a safer environment, and without eyestrain or glare. Sky-lighting will be considered in order to minimize the use of day time electrical lights. LED lights and other energy saving electrical systems will be considered to make use of day time lights to minimize electricity energy consumption by Project.

10.4.3 Work Environment Temperature

During working hours, temperatures inside the buildings may be considered as reasonable, ranging in some areas between 16° and 25°C. The surrounding temperatures outside, however, usually vary from around 34° to above 36° on sunny days. Efforts will be made to schedule work during the early part of the day which will help to mitigate workers' exposure to high temperatures.

10.4.4 Ventilation

Offices would be equipped with air conditioners, which would be serviced regularly by contracted technicians. Portable fans and heat extractors would be used in the production area to achieve an adequate air flow at specific work areas to keep operators cool.

10.4.5 Personal Protective Equipment (PPE)

Protective clothing, hard hats, goggles, face masks, hair covers, gloves, and safety footwear constitute the typical forms of protective equipment that are provided to workers. The appropriate use of the PPEs would be demanded to ensure reduced risks of hazards.

Aside from ensuring their adequate supply, maximizing the chances of obtaining good fit and comfort for everyone is a really important objective for Management. Sectional heads and line supervisors would have the duty and authority to enforce the proper use of required PPE as well as sanction employees who fail to adhere to safety and hygiene standards.

10.4.6 Dress Code

Workers working in hazardous environments shall receive specific guidelines as to what should and should not be worn. The Project does not accept the wearing of loose clothing and large or dangling jewellery by factory workers while on the job to prevent being entangled in the driver of machine.

Workers would be provided with corporate attires to ensure conformity with appropriate safety requirements in relation to style, comfort, quality and safety.

10.4.7 Medical Monitoring

As a condition of employment, all new personnel will undergo and must successfully pass a baseline medical examination to demonstrate fitness for duty. The Project will undertake periodic (at least once a year) screening of existing employees, and medical screening results are reviewed to monitor any physical changes between visits as well as identify the workers requiring support.

Common tests performed would include those for the diagnosis of life-threatening illnesses and communicable disease, such as tuberculosis, HIV/AIDS, typhoid, hepatitis B and C.

The Project will work with several health centres in the vicinity, but will have most cases referred to the Project privately-operated clinic, whereas more complicated cases continue to be referred to the Regional Hospital in Cape Coast.

Meanwhile, individual medical records are kept confidential and stored securely, albeit made accessible, within the framework of certification only, to inspectors of the district's Environmental Health and Sanitation Unit whose authority to award health certificates is recognized by the various regulatory bodies.

10.5Health and Safety Administration

10.5.1 Corporate Responsibility

The Project is intended to establish a health facility to cater for the health need of the working personnel and residents of the nearby communities. This would also be considered as a part of the corporate social responsibility of the Project to the community.

The Project’s growth depends on its employees hence will ensure all the necessary administrative support needed is made available to promote health and safety of both employees and equipment.

10.5.2 Health and Safety Committee

The Project, by nature of its size and structure, would establish Health and Safety Committee to facilitate and ensure consistent consideration of environmental, health and safety matters. More also the Committee would be responsible for implementation of all action related to health and safety and monitoring of the outputs and outcomes of these actions.

10.5.3 The Role of Employees

The employees of the Project will be engaged and made part of the implementation processes and actions to promote high sense of ownership and control.

10.5.4 Health and Safety Education

As part of the implementation of the environment, health and safety action plan, a rigorous educational campaign would be instituted to ensure that every employee is well knowledgeable in issues relating to environment, health and safety as well as the relevant aspects of the action plan.

10.5.5 Hygiene and Sanitation Practices

The Project in order to ensure the safety of its workers will ensure the following:

a) Develop a culture throughout the plant in which employees assume an operative role in controlling sanitation in their units.

b) Ensure that everyone, from management to production workers, understands sanitation and hygiene issues.

10.5.6 Health and Safety Action Plan

The Project would secure instruments for monitoring employee exposures to noise hazards. The equipment would be carefully checked and calibrated by the Ghana Standards Authority to ensure that the measurements are accurate. Audiometric testing of various stall personnel would be implemented to establish baseline audiograms of employees before exposure to high noise area of 85 dBA or above.

In addition, regular monitoring of high noise areas would complement decision of Audiometric testing.

Table 10-2 Summary of Health and Safety Action Plan

Impact	**Mitigation Action**	**Actual Action**	**Objective**	**Target**	**Budget (GHS)**	**Timeframe**	**Responsibility**
Occupational Health and Safety	Personal Protection and regular health screening of workers	Provision of PPEs Health screening	Reduce or eliminate residual health and safety impact	Workers and Visitors	100,000.00	2017 to 2019	Health and Safety Committee
Fire Hazard	Fire protection system	Installation of fire protection system and regular inspection of the system	Prevention of fire hazards	Total prevention of fire	2,518,000.00 USD	2020	Project Development Team
Incidents/Accidents	Awareness and training	Institute regular health and safety durbars and training programme	Reduce the incidence of accidents	Total elimination of incidence of accident	15,000.00	2017 -2019	Health and Safety Committee
Total					115,000.00		

10.6Environmental Quality and Monitoring Plan

There will be regular environmental monitoring based on requirements from the Environmental Protection Agency. The table below gives a summary of the requirements for the environmental monitoring.

Table 10-3 Summary of Environmental Monitoring Plan

Parameter	**Indicators**	**Frequency**	**Method**	**Reporting procedures**	**Monthly Cost (GHS)**	**Responsibility**
Ambient Air quality (5 sampling sites)	TSP, PM_{10}, NO_x, SO_x	Once a month	On site measurement of air quality and analysis	Quarterly reporting to EPA	450,000.00	Environmental Manager, Environmental Consultant and Service Provider
Air Emission	TSP, PM_{10}, NO_x, SO_x,	Continuously	Online measurement of emission quality and analysis	Online reporting to EPA		Environmental Manager, Environmental Consultant
Noise (5 sampling sites)	Ambient noise	Once a month	On site measurement of noise level and analysis	Quarterly reporting to EPA	36,000.00	Environmental Manager, Environmental Consultant and Service Provider
Seawater Quality	pH，Total dissolved solids, Total suspended solids, BOD, COD, turbidity, conductivity, Oil and Grease，Lead，Iron，Zinc，Copper，Total Chromium.	Monthly	Seawater sampling and analysis	Quarterly Report	16,000.00	Environmental Manager, Environmental Consultant and Service Provider
Effluent (2 sampling sites)	Total dissolved solids, Total suspended solids, BOD, COD, turbidity, conductivity, colour, chlorine, E. coli, Total	Once month	Sampling and laboratory analysis of effluent	Quarterly reporting to EPA	16,000.00	Environmental Manager, Environmental Consultant and Service Provider

Parameter	**Indicators**	**Frequency**	**Method**	**Reporting procedures**	**Monthly Cost (GHS)**	**Responsibility**
	coliforms, Ammonia, nitrate, cadmium, oil and grease.					
Heat stress	Temperature in the work environment	Once a month		EPA and Factories Inspectorate Dept	18,000.00	Environmental Manager, Environmental Consultant and Service Provider
Luminous intensity	Light intensity in the work environment	Once a month	On-site measurement	EPA and Factories Inspectorate Dept. (FID)	18,000.00	Environmental Manager, Environmental Consultant and Service Provider
Water	Process water and non-process water consumption	Daily	On-site measurement	EPA Akoben	–	Environmental Manager, Environmental Consultant
Electricity	Electricity production and consumption	Daily	On-site measurement	EPA Akoben	–	Environmental Manager, Environmental Consultant
Employment	Persons employed	Monthly	Head count	EPA Akoben	-	Environmental Manager, Environmental Consultant
Complaint	Public complaints	Monthly	Physical count	EPA Akoben	-	Environmental Manager, Environmental Consultant
Total					**538,000.00**	

10.7 Reporting schedule

There are various types of reports to be submitted to the regulatory Agencies. The table below indicates the types of report and corresponding actions to be taken.

Table 10-4 Summary of Report Types

Report type	Frequency	Responsibility	Regulatory Agency
Environmental quality performance	Quarterly	Consultant/EMC	EPA
Annual environmental report	Annual	Consultant/EMC	EPA
Environmental Management Plan	3 years	Consultant/EMC	EPA
Heat stress and luminous intensity	Quarterly	Consultant/EMC	EPA/FID
Boiler maintenance report	Annual	Consultant/EMC/Maintenance Dept.	EPA/FID

10.8 Emergency Preparedness and Response Plan

The development and operation of the coal-fired power plant has its associated hazards and risks and hence the Project shall take all necessary steps to mitigate the impact these hazards will have on the staff and the environment. The main aim of the emergency preparedness and response plan is to provide necessary guidelines for assistance to ensure safety of people, protection of environment, protection of installations and restoration of operation.

The objectives of the plan would seek to achieve:

a) Improved state of preparedness to meet any contingency/emergencies.
b) Enhanced response time in organizing resources to assist in rescue and response.
c) Key resources, man power, materials & equipment needed to make the plan operational are identified and organized.
d) Optimized the use of combined resources for emergencies.

Detailed standard operating procedure will be developed and used for emergency response during accident. Some of the risk/hazards which may occur include the following:

a) Fire hazards
b) Chemical Spillages and leakages
c) Air pollution

d) Explosions
e) Equipment failures and malfunctions.

The Project would be prepared for any unexpected emergencies which may occur during the operation of the plant. This would require the Project responding to any emergency situation within the shortest possible time.

The Project will plan also put in place an emergency response is putting in place all necessary emergency response plan required.

An emergency response team will be established to lead efforts during an accident. The emergency response team will be made up of selected members from all the departments who include:

a) Production Dept.
b) Wastewater treatment plant Dept.
c) Maintenance Dept.
d) Health and Safety Dept.
e) Administration Dept.

These team members shall be given rigorous training on rescue and emergency responses to any potential accident likely to occur within the plant. They shall also lead coordination efforts to ensure safety within the plant.

The emergency response team shall have the following responsibilities:

a) Direct actions within the affected area taking into consideration the priorities for safety of plant / installation, personnel, minimum damage to plant & equipment, property and the environment.

b) Liaise with fire and security personnel for immediate action.

c) Ensure that all non-essential workers / staff in the affected area are evacuated or rescued to safer places.

d) Set up communication points

e) Report all developments and requirements / assistance needed.

f) Preserve all evidences so as to facilitate any inquiry into the cause and circumstances which caused or escalated the emergency

g) Coordinate with other public agencies for necessary security, finance, medical and law & order etc.

The emergency response team shall liaise with the following public agencies;

a) Ekumfi Municipal Assembly
b) Ghana National Fire Service
c) The Winneba District Hospital and Cape Coast Regional Hospital
d) National Ambulance Service
e) Environmental Protection Agency
f) Ghana Police Service

In order to have an effective response to emergency situations, there will be three (3) types of response elements established. These response elements include:

a) Operational response – this type of response is to bring the accident/incident under control and ensure that normal activities can continue.

b) Management response – this involves the allocation of resources and making critical decisions.

c) Communication response – this will involve the communication with employees and their families, officials, other agencies and the media.

Actions necessary at the time of emergency response may include:

a) Exchange and provision of information in terms of event description, its severity and action plan.

b) Preparation of a checklist to be used to ensure all evacuation and rescue procedures are followed.

c) Identification of resources needed and their deployment in relation to technical experts, man power, equipment, spare parts and other materials.

d) Early restoration and facilitation of re-inspection as needed.

e) Field/site surveys including damage assessment.

f) Post-accident investigation and analysis and future strategy.

10.9Post Emergency Response

Actions necessary in post emergency/accident situation may include:

a) Damage Assessments: Immediately following an accident, an initial damage assessment must be performed by the plant emergency response team.

b) Hold meetings with staff and discuss the departments' performance.

c) Assess the condition of structures under department's jurisdiction and carryout repairs as needed.

d) Assess the condition of departmental vehicles and equipment and organize their repair and maintenance.

e) Draw lessons from the performance and identify actions to be taken for future improvement.

f) Review and document or record actions taken.

g) Implement action plan for improving future performance.

h) Training of staff in emergency response situations.

i) Develop checklist and contingency plans.

11 DECOMMISSIONING

The chapter describes the activities to remove the installed facilities and equipment and return the site to a condition as close to a pre-construction state as feasible to ensure public health and safety, environmental protection, and compliance with applicable regulations. It further outlines the procedures and activities for reclamation during and after completion of project operation as well as measures to be taken to prevent unnecessary or undue degradation.

Decommissioning may become necessary for reasons including:

- Obsolescence with low efficiency
- Progressively the power plant having difficulties in meeting the allowable emission levels demanding pollution controls making it economically uncompetitive.
- Power plant having outlived its useful economic life and becoming increasingly uneconomic to operate.

Several considerations would be taken into account in decommissioning the coal-fired power plants including the need to plan and take strategic steps to contain costs and prevent spiraling liabilities. The basis of these considerations may be the economic model, technology assessment and environmental issues and also options for the site. Seeking professional assistance in this regards would be given due consideration from the beginning.

However, it is considered that the power plant decommissioning would involve primarily demolition and remediation.

The activities would involve:

- Permitting
- Environmental and ecology assessment including ground investigation, noise mitigation and pollution.
- Structural demolition
- Site dismantlement and scrap recovery
- Waste disposal
- Environmental clean up
- Site remediation and restoration
- Costing

The Project would engage the services of professional demolition contractors to carry out the work and ensure appropriate measures would to be taken to prevent unnecessary or undue degradation.

Decommissioning may lead to Residual Liability Costs arising from the legacy of the coal plant, which can attract lawsuit for nuisance, trespass and negligence and therefore increase the shutdown costs. Precautionary legal solutions include letters of credit, escrows, holdbacks, performance bonds or insuring excess liability,

Depending on the market for scrap metal, the dismantled coal-fired power plant may be sold to the local steel industry or reshipped to China to offset substantial cost.

Auxiliaries such as pumps, piping, boilers, ductwork and air pollution controls will require special handling.

12 CONCLUSIONS & RECOMMENDATIONS

VRA and SEC have carried out an Environmental and Social Impact Assessment of its proposed 2X350 Supercritical Coal-fired Power Generating Plant to be situated along the coast of Aboano in the Ekumfi District of the Central Region.

The ESIA team has carefully evaluated the project design and environmental pollution controls and have identified and assessed the likely residual impacts and recommended appropriate mitigation measures to eliminate, minimize or compensate where necessary.

The likely primary potential hazards are identified to encompass air quality degradation, noise nuisance, seawater quality degradation, soil and water resource quality degradation, and occupational safety and health issues of employees and community health and safety issues. Consequently, the Project has carefully evaluated the residual impact in the context of EPA guidelines, IFC Environmental Health and Safety Guideline and in line with Equator Principles and China Banking Regulation.

The ESIA has therefore recommended appropriate mitigation measures aiming to minimize or if possible eliminating the impacts identified.

In conclusion, the development and operation of 2X350 MW Supercritical Coal-Fired Power Plant is unlikely to have significant adverse effect on the environment with climate change. The health and safety situation of the workers and the community is not likely to be affected by the implementation project development.

The project, in general is likely to have immense social and economic benefits to the surrounding communities and the nation as a whole.

The project would supplement power generation capacity and supply requirements of the country whiles boosting Ghana’s realization of stable and secure baseload to create the needed base for the subsequent development of renewable power generating sources to meet the continued growing energy needs of the country both presently and in the future.

The project will again influence the socio-economic lives of the inhabitant and locals through the provision of decent jobs and consistent income flow both directly and indirectly, technology transfer and diffusion as well as boosting the commercial activities of the people.

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14 APPENDICES

Appendix 1: General Layout of the Project

Appendix 2: Water Balance

Appendix 3: Coal Supply MoU

Appendix 4: Coal Ash Utilization MoU

Appendix 5: Utilization Scheme of Coal Ash

Appendix 6: Sites Technical Evaluation and Comparison

Appendix 7: Background Information Document for Scoping Consultation

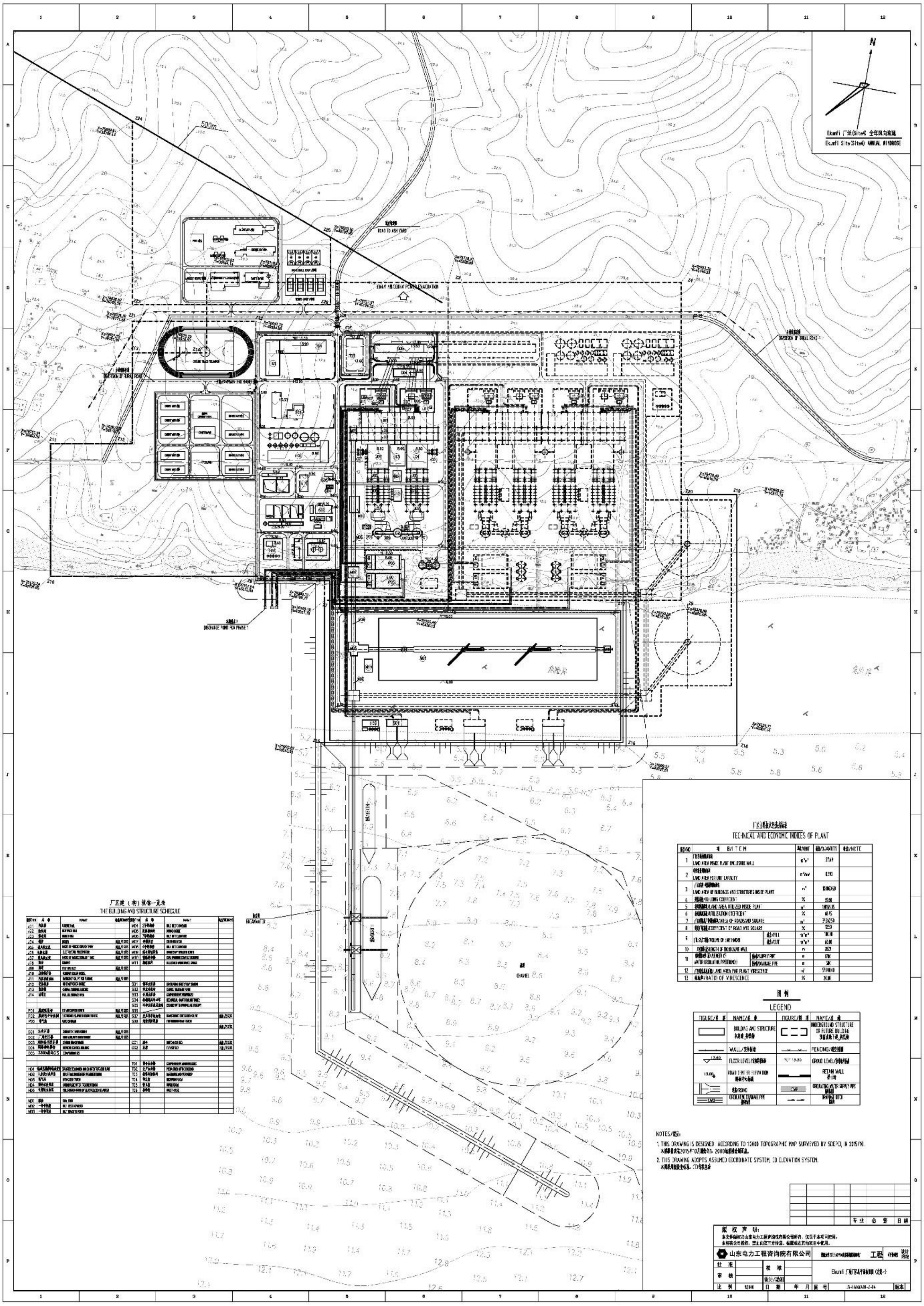
Appendix 8: Consultation Records

Appendix 9: Scoping Notice

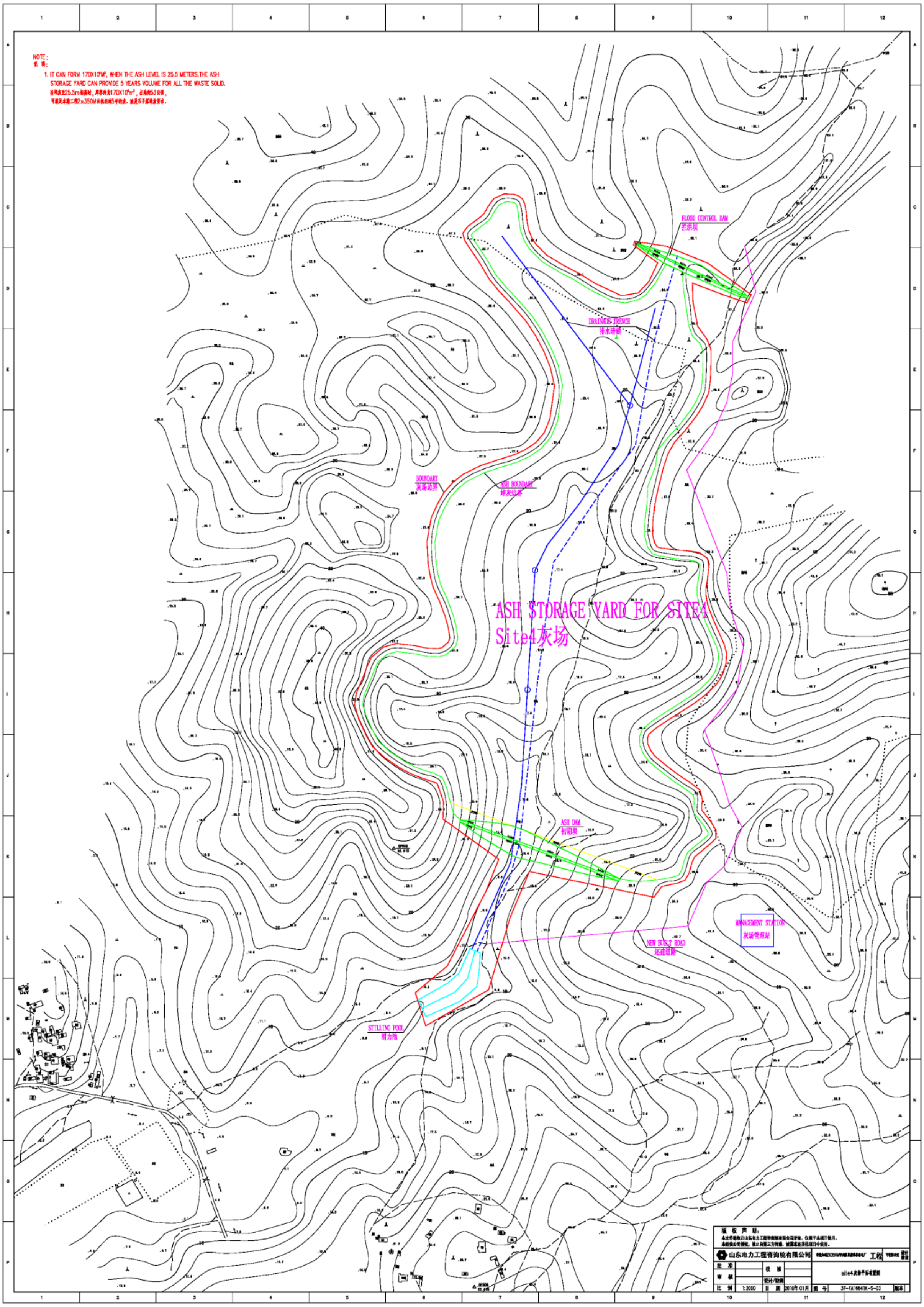
Appendix 10: Profile of ESIA Team

Appendix 1: General Layout of the Project

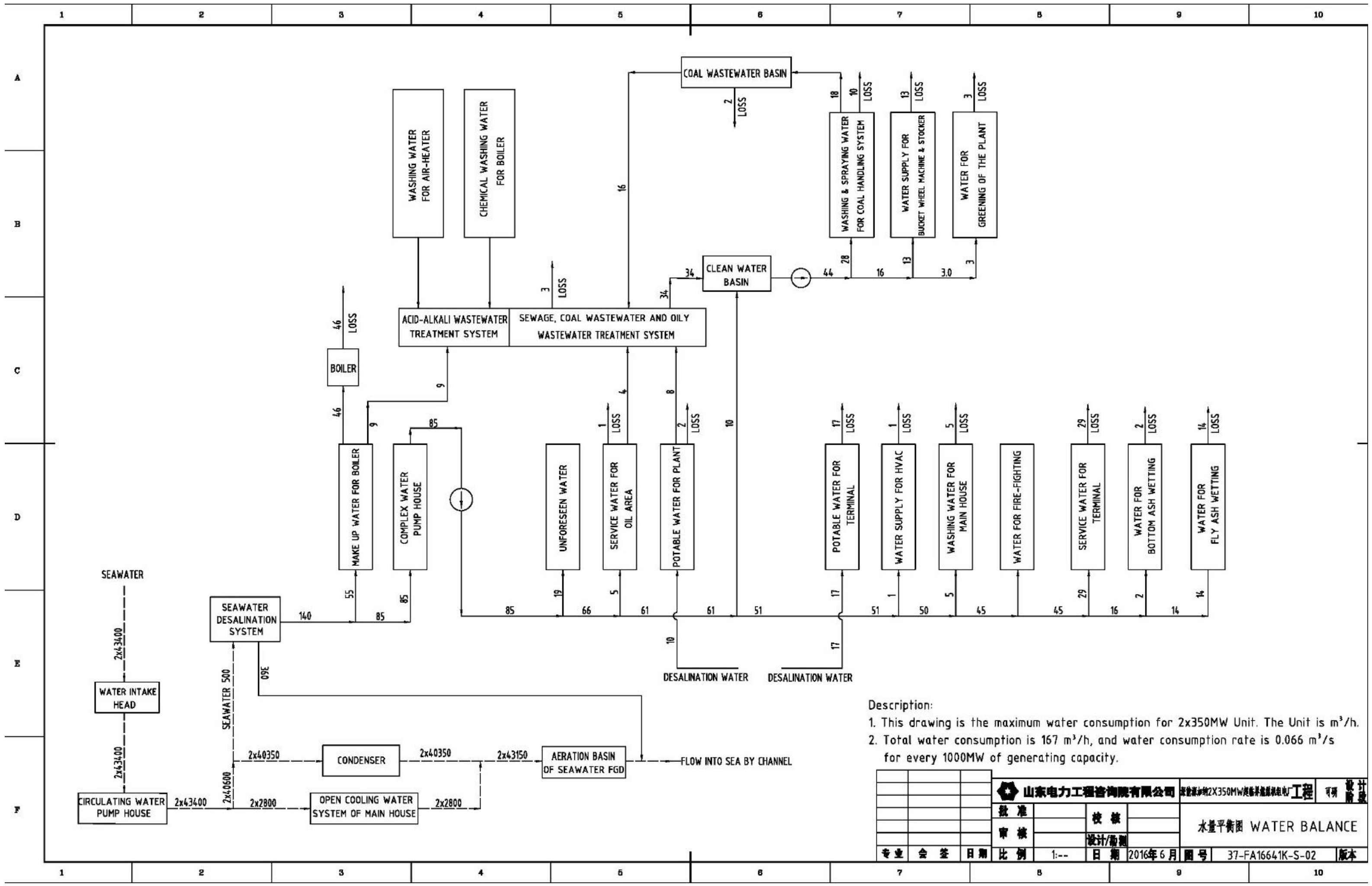
Layout of the Power Plant



Layout of the Coal Ash Yard



Appendix 2: Water Balance



Appendix 3: Coal Supply MoU

terms and conditions of such offtake agreement will be set out in a definitive, legally binding agreement (the "Definitive Agreement").

Indicative specifications of Coal:

(1)	Total Moisture (arb):	12% max
(2)	Inherent Moisture (adb):	3.5% typical
(3)	Ash (adb):	15% max
(4)	Volatile Matter (adb):	22% min
(5)	Total Sulphur (adb):	1.0 % max
(6)	Net Calorific Value (arb):	5000-6000 kcal/kg

The detailed specifications, price, transportation, acceptance, payment and other related matters will be negotiated and mutually agreed upon in any Definitive Agreement.

2. Confidentiality

(a) Subject to sub-clause (b) below, the Parties agree that the existence of and terms of this MOU, and the existence of and content of any negotiations between the Parties relating to an offtake agreement ("Confidential Information"), are strictly confidential and shall not be disclosed by either Party to any third parties without the prior written consent of the other Party, or except as a Party may be required to disclose by any applicable law or order of any government agency. For the avoidance of doubt, nothing in this MOU requires any disclosure to be made by either Party. To the extent that any press releases or public announcements are required for whatever purpose to be made in respect of any negotiations related to this MOU and/or to any future agreement, neither of the Parties will make any statement to any securities exchange, give any press release or make any public announcement, including a statement to shareholders, without the prior written consent as to the wording of such press release or public announcement first having been obtained from the other Party.

(b) A Party may disclose Confidential Information to those of its officers, employees and professional advisers as are strictly necessary for the purpose of the matters contemplated in this MOU and have agreed to be bound by the provisions of this clause.

5

Appendix 4: Coal Ash Utilization MoU

MEMORANDUM OF UNDERSTANDING

谅解备忘录

This Memorandum of Understanding (hereinafter called "MOU") is established and signed on this day of February 17th, 2016 by and between:
本谅解备忘录由以下公司在 2016 年 2月17日 确定并签署：

SHENZHEN ENERGY GROUP CO., LTD (hereinafter called **"SEC")**, a company duly incorporated under the Laws of the People's Republic of China in 1993, and having its Headquarters at No. 2068, Shennan Middle Road, Futian District, and Shenzhen, Guangdong, China
深圳能源集团股份有限公司（以下简称"SEC"），于 1993 年在中国人民共和国法律下正式注册成立，其总部位于中国广东省深圳市福田区深南中路 2068 号。

/ VOLTA RIVER AUTHORITY (hereinafter called **"VRA")**, a body corporate established under the Volta River Development Act, 1961 (Act 46) having its Registered Office in Electro-Volta House, 28th February Road, Accra, Ghana
/ 沃尔特河管理局（以下简称"VRA"），在加纳 1961 年沃尔特河发展法令（法令 46）下成立，其注册办公所在地位于加纳阿克拉市 2 月 28 日路 Electro-Volta 大厦。

and
和

CHINA STATE HUALONG CONSTRUCTION (GH.) LTD. (hereinafter called **"CSHLC")**, whose registered office is situated at P. O. Box 10128, Accra-North, Ghana.
中国华陇建筑（加纳）有限公司（以下简称"中建华陇"），其注册地点位于加纳阿克拉市北 10128 号。

SEC/ VRA, and CSHLC are collectively referred to as "Parties" and individually referred to as "Party".
以下 SEC/ VRA 和中建华陇被统称为"双方"，并分别简称为"一方"。

WHEREAS:
A. SEC in collaboration with VRA, intends to develop a 2×350MW Supercritical Coal-Fired Power Plant (including affiliated coal handling terminal), in the Central Region of Ghana. The project is planned to commence in August 2016 with all related preparation works accomplished, the 2×350MW units will be completed and put into

Page 1/5

commercial operation from 2019 to 2020.

A. SEC 与 VRA 联合计划在加纳中部地区建造一座 2x350WM 超临界燃煤发电厂（含专用煤码头）。该项目计划在 2016 年 8 月具备开工条件，在 2019 年到 2020 年分别完成两台机组的建设及投入商用。

B. CSHLC is a comprehensive group corporation mainly engaged in industrial and civil buildings, construction of municipal roads and bridges, and international engineering contracting, and also deals with real estate development, decoration engineering, service works, building materials sales, concrete sales, construction machinery & equipment leasing, aggregates production and sales, import and export trade, pharmaceutical production and hotel management. And CSHLC is interested in purchasing the fly ash and slag produced in the above-mentioned Coal-Fired Power Plant.

B. 中建华陇是以工业与民用建筑、市政路桥建设和国际工程承包为主业，集房地产开发、装饰工程、安装工程、建材销售、商砼销售、施工机械、设备租赁、机碎石料生产与销售、进出口贸易、药品生产及酒店经营、管理为一体的综合性集团公司，并有意向购买上述燃煤电厂产生的飞灰、炉渣。

C. The MOU is a statement of mutual intention with respect to the sale and purchase of fly ash and slag as contemplated above.

C. 本谅解备忘录是双方对销售和购买飞灰、炉渣形成合作的共同意向的声明。

The Parties confirm their intention to work together to negotiate a fly ash and slag sale agreement (**"Sale Agreement"**) in accordance with the following provisions:

在以下前提下，双方确认协商并形成飞灰、炉渣的销售协议（以下简称“销售协议”）的合作意向：

1. The purpose of this MOU is to set out basic terms of the proposed Sale Agreement between the SEC/ VRA and CSHLC.
1. 本谅解备忘录的目的是为 SEC/VRA 与中建华陇之间以后签订的“销售协议”设定基本的条款。

2. Indicative Terms of Sale Agreement:

   a) Quantity

   CSHLC shall endeavor to purchase up to 300 thousand tons of fly ash and 30 thousand tons of slag per calendar year when the above-mentioned Coal-Fired Power Plant in Ghana, becomes operational.

   b) Agreement Terms

   The Parties shall negotiate and agree on the detailed terms on specification, price, transportation, acceptance, payment and other related matters of fly ash and slag in respect of the Sale Agreement. For the avoidance of doubt, all terms of the Sale

Agreement shall be mutually agreed between the Parties before signing the Sale Agreement.

2. “销售协议”的参考条款

a) 数量：在上述燃煤机组投产后，中建华陇每年必须尽量购买 30 万吨的飞灰和 3 万吨的炉渣。

b) 协议条款：在“销售协议”中，双方必须对飞灰、炉渣的规格、价格、运输方式、接收方式、付款方式等相关事务协商并达成一致。为避免疑义，在签署“销售协议”之前，双方必须就“销售协议”中的所有条款达成一致。

3. Non-Binding Memorandum: The Parties agree that this is a non-binding MOU only and does not represent any agreement between the Parties or a commitment to enter into an agreement. This MOU is solely intended to set out the basic indicative terms of the proposed Sale Agreement to be entered into between the Parties and is not intended to create any legal relationship between the Parties or create any legally enforceable rights or obligations on either Party. In particular, neither Party agrees to exclusive negotiations with the other Party.

3. 非约束性谅解备忘录：双方同意，这是一个不具约束力的谅解备忘录，并不代表订立一项协议或产生协议影响的承诺。本备忘录完全是为了阐明双方以后签订的“销售协议”中的基本条款，并无意建立双方之间的法律关系或对任何一方产生任何具有法律约束力的权利或义务。特别是，任何一方无需同意与另一方进行独家谈判。

4. The confidentiality clause of this MOU shall be valid and effective from the date of the date of this MOU as set out above until the earlier of (a) the execution of a definitive Sale Agreement between SEC/ VRA and CSHLC in connection with this MOU; (b) the issuance of a notice by SEC/ VRA announcing the cancellation of the Project or (c) 21 December 2019, unless otherwise agreed by the Parties.

4. 除非双方另有约定，本谅解性备忘录中的保密条款自备忘录签署之日起生效，并在以下日期中较早的一项之前保持有效：（a）SEC/VRA 与中建华陇签署“销售协议”之日；（b）SEC/VRA 声明取消项目之日；（c）2019 年 12 月 21 日。

5. Governing Law and Dispute Resolution: The MOU shall be governed by and construed in accordance with the Laws of China. If any dispute, controversy or claim of whatever nature arises under, or out of or in connection with this MOU, the Parties shall use all best endeavors to resolve the matter amicably.

5. 适用法律和争议解决：本谅解备忘录受中国法律管辖，并按中国法律解释。如果有任何争议、纠纷或任何在本备忘录之下、之外或之内的要求产生，双方应利用一切尽最大努力友好地解决这一问题。

6. Confidentiality: Each Party agrees to treat the information received from the other Party as confidential and use it only for the purposes intended under this MOU

and disclose such information to its employees, consultants or advisors who strictly need such information for the said purposes and who are bound by similar confidentiality undertaking.

6. 保密条款：双方同意把从另一方接收到的信息作为保密信息，并只能将这些信息用于达到本备忘录预期的目的，而将这些信息透露给其员工、咨询公司或顾问。员工、咨询公司或顾问在得到信息后，只能将信息用于上述目的，并受到同样保密承诺的约束。

7. Announcement: If any Party wished to publicly announce the existence of this MOU, that Party shall procure the other Party's consent in writing.

7. 公告：如果任何一方希望公开宣布本谅解备忘录的存在，该方应预先获得另一方的书面同意。

IN WITNESS WHEREOF, the Parties have caused this Memorandum of Understanding to be executed as of the Effective Date first written above.
兹证明，双方已于本谅解备忘录首页所载之生效日期执行。

Executed for and on behalf of **Shenzhen Energy Group Co., Ltd.**

Signature: Date: 17/2-2016

Name: Zhengjun Wang

Title: Deputy Manager of Shenzhen Energy Group Ghana Coal-fired Pre-project Office

深圳能源集团股份有限公司代表：

签名： 日期：

姓名：王正军

职位：深圳能源集团加纳煤电项目前期办公室副主任

Executed for and on behalf of **Volta River Authority**

Signature: Date: 17-02-2016

Name: Jonathan Amoako-Baah

Title: VRA Team Leader of 2x350 MW Supercritical Coal-Fired Power Plant Project

沃尔特河管理局公司代表：

签名：日期：

姓名：Jonathan Amoako-Baah

职位：加纳 2x350MW 超临界燃煤电厂项目 VRA 团队组长

Executed for and on behalf of **China State Hualong Construction (Gh.) Ltd.**

Signature: Date: 17/02/2016

Name: Guo Xiao

Title: General Manager

中国华陇建筑（加纳）有限公司代表

签名：日期：

姓名：郭 啸

职位：总经理

Page 5/5

Appendix 5: Utilization Scheme of Coal Ash

1. General

The Coal Ash (Raw Ash) produced in the power plant will be sorted into different types as Fine Ash and Coarse Ash.

The Fine Ash can be applied in cement industry, concrete batching stations and large-scale building projects. The Ghanaian Standard for cement production GS 22:2011, makes provisions for the utilization of the coal ash. It states that: "Minor additional constituents if present shall be one or more of limestone, granulated blast furnace slag, pozzolana, pulverized-fuel ash (fly ash) or other fillers". And the construction of the BUI Hydroelectric Dam made use of huge volumes of the coal ash which was imported into Ghana from China.

The Coarse Ash and Slag may also be grounded into Fine Ash by the Grinding System, or be made into light-weight aerated concrete blocks according to the demand of the market.

2. System Configuration

2.1 Transportation and Storage System

The Ash Pipeline (shown in picture 1 and 2) will be installed after the Electro-Static Precipitator (ESP) of the power plant. And the fly ash will be transported to the Ash Storage Tank (shown in picture 3) in the coal ash storage yard through the Ash Pipeline by means of compressed air.

Picture 1. Ash Pipeline

Picture 2. Ash Pipeline

Picture 3. (1)Ash Storage Tank and (2)Surge Bunker

Picture 4. Loading Operation

In the loading operation process, which is shown in Picture 4, the coal ash in the Ash Storage Tank will be sent to the elevator by the screw conveyor at the bottom of the Tank, then into the Surge Bunker by the elevator, finally into the silo of the truck by the offloading facility at the bottom of the Bunker and transported to the market.

Therefore, the transportation and loading process will allow few dust emitting outside. And the transportation pressure of the power plant would not be increased since the Ash Storage Tank is located outside the plant. This will have no direct or significant impact on the neighboring communities.

Three Ash Storage Tanks, with a volume of 30,000 tons individually, will be provided on site to ensure the capacity of the storage, sorting and production. The three Tanks are designed to reserve Raw Ash, Fine Ash, and Coarse Ash separately to meet the requirement of the sorting system below.

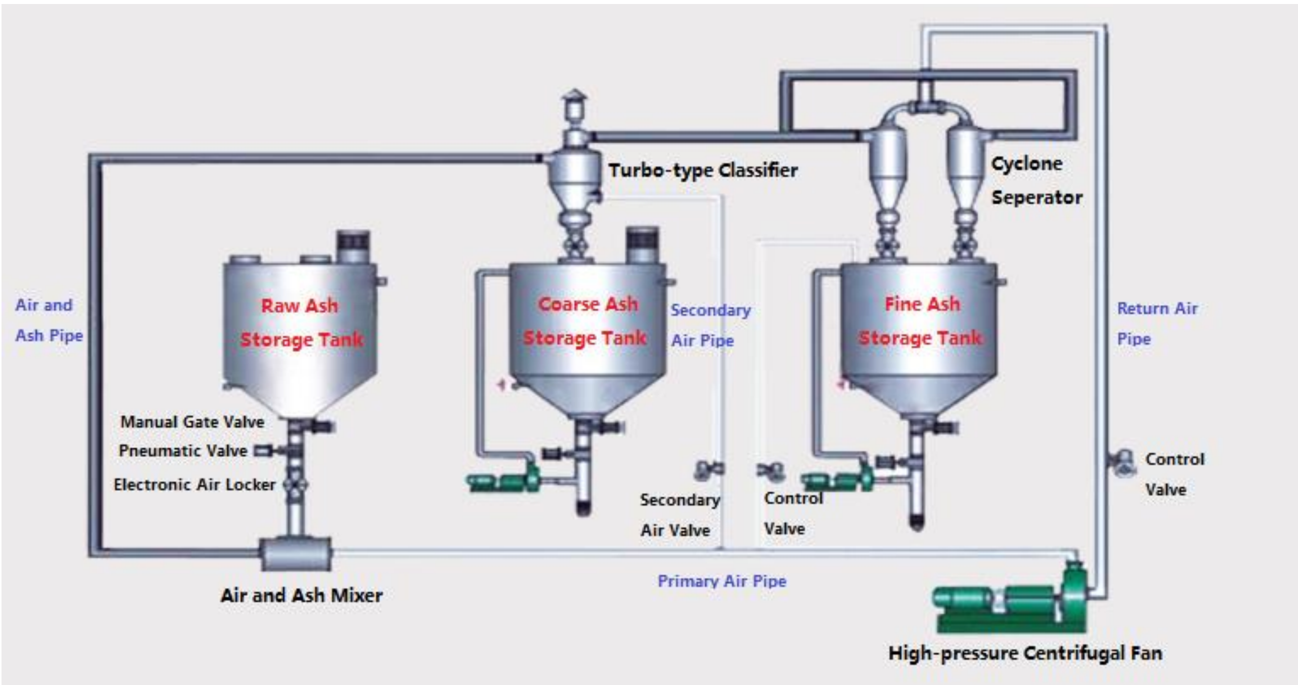
1.2 Sorting System

Capacity: 300,000 tons of coal ash (Raw Ash) per year

Product: Fine Ash

Picture 5. Sorting System

The sorting equipment intended for use is a Turbo-type Classifier, and the working process is explained below.



Picture 6. Working Process of Sorting System

The mixture of air and raw ash is evenly nebulized by the Mixer, then transferred to the Classifier because of the negative pressure. In the grading cylinder of Classifier, ash particles are subjected to centrifugal force Fc (proportional to the cube of the particle diameter) and aerodynamic resistance Fd (proportional to the particle diameter) simultaneously.

For Fine Ash particles Fd> Fc, so the particles will go through the turbine blades, then to the Cyclone Separator, to be collected in the Fine Ash Tank as final product. On the contrary, Coarse Ash particles will remain in the Classifier for a long time because the comprehensive effect of resistance Fc and secondary air, and then fall down into the Coarse Ash Tank after an electric air locker, wrapping little Fine Ash particles. Thus the separation efficiency is generally 75% or more.

The exhaust containing traces of dust will pass through the Return-air Pipe by the High-pressure Centrifugal Fan, and then go back to the primary air pipe again, forming a closed loop. A small part will go into the Fine Ash Tank, then bag-type dust collector on the top of the Tank and finally be discharged into the air.

In the process the impeller speed, air volume and velocity are all adjustable, which makes digital control of the processing and quality available. And the system can handle very large amounts of material (currently 50 tons per hour), without affecting their performance.

In conclusion, the device has following advantages:

(1) The technology is mature, stable and reliable, and the control is simple.

(2) The system forms an enclosed circle, without secondary pollution. And the dust of the exhaust has been removed before emission.

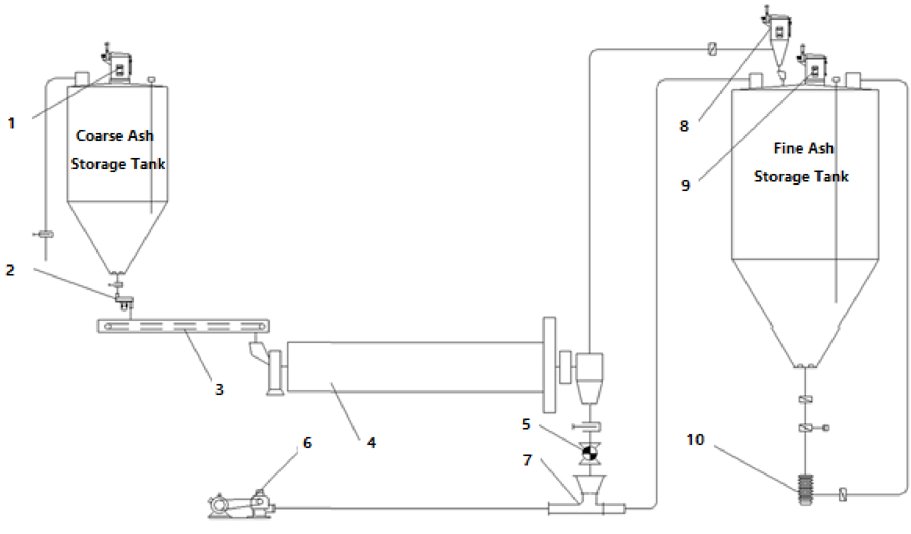
2.3 Grinding System

Capacity: 200,000 tons of Coarse Ash and Slag per year

Product: Fine Ash

After the Sorting system, the Coarse Ash and Slag will be processed into the Grinding System to be grounded into qualified fine ash. The grinding equipment intended for use is a High-efficiency Ultra-fine Ball Mill, and its working process is introduced below.

No.	Name
1	#1 Bag-type Dust Collector
2	Electronic Metering Scale
3	Chain-linked Conveyer
4	High-efficiency Ball Mill
5	Air Lock Feeder
6	Roots Blower
7	Continuous Delivery Pump
8	#2 Bag-type Dust Collector
9	#3 Bag-type Dust Collector
10	Offloading Facility



Picture 7. Working Process of Grinding System

(1) Feeding Process. A Manual Gate Valve, and a Steady-flow Screw Machine with variable voltage and variable frequency is installed at the bottom of the Coarse Ash Storage Tank. The Coarse Ash is continuously transferred to the Electronic Metering Scale by the Screw Machine, then onto the Chain-linked Conveyer and delivered to the entrance of the High-efficiency Ultra-Fine Ball Mill.

(2) Grinding Process. An open flow process is adopted as: ash entering the mill, grinding, and existing. Because of the function of the Ultra-Fine Ball Mill, the ash produced is able to meet the fineness requirement of the Fine Ash without having to go through screening or sorting process. And quantitative graded forging steel will be added into the mill to ensure the quality of the ash and meet the design requirements of the project.

(3) Output Process: The ash produced will slip into the buffer silo at the discharging position of the Mill. A high level gauge installed on the buffer silo will send alarm signals in case of full storage to prevent overflow. A low-pressure Continuous Delivery Pump is arranged at the bottom of the buffer silo, and the ash will be delivered into the Fine Ash Storage Tank through the ash pipe by the Roots Blower.

The system has the following advantages:

(1) The technology is mature, reliable, and the structure is simple.

(2) The system is easy for operation, maintenance and management.

(3) The good sealing makes negative pressure operation reliable, which effectively prevent dust flying in the production process and meet environmental requirements.

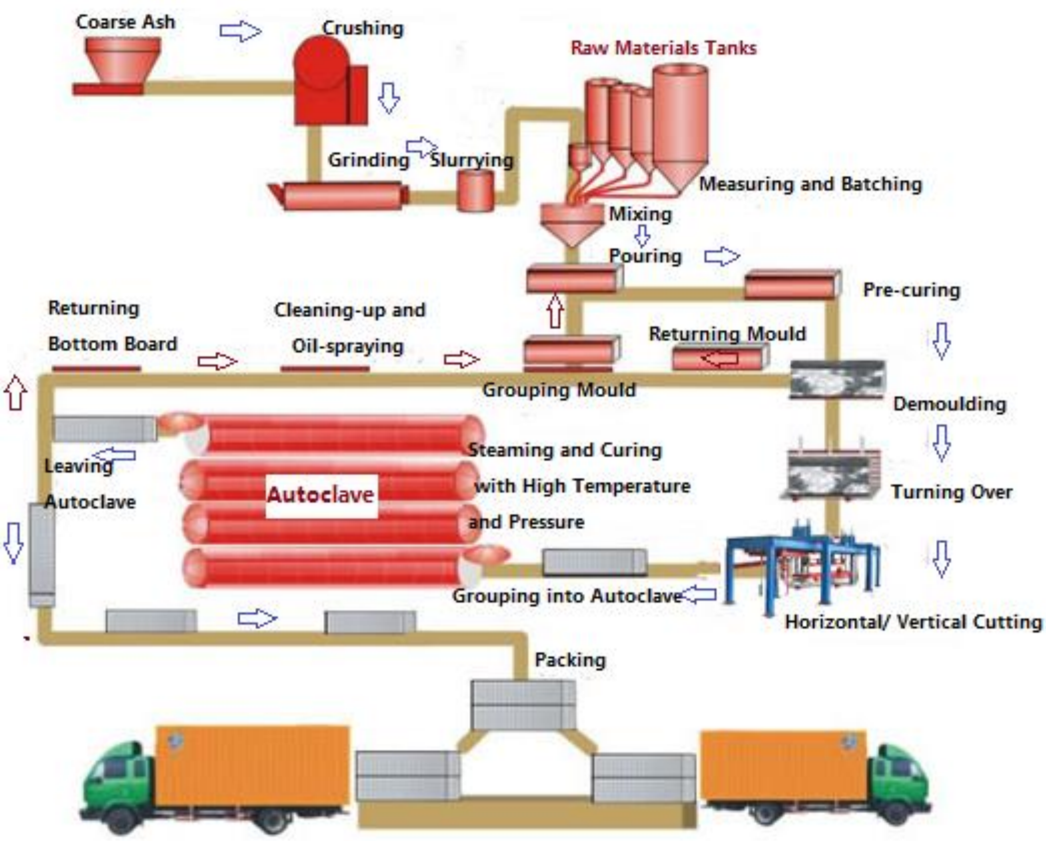
2.4 Light-weight Concrete Block Manufacture System

Capacity: 200,000 tons of Coarse Ash and Slag per year

Product: 300,000 tons of Light-weight Concrete Blocks per year

Besides the grinding system, the sorted coarse ash and slag can also be utilized to make light-weight blocks, thus improving the diversity of the products. Moreover, the sludge and waste water produced by the ash storage yard and power plant can also be used in this process, thus achieving zero waste emission.

Picture 8. Light-weight Concrete Block Factory



Picture 9. Working Process of Light-weight Concrete Block Manufacture System

The production process, shown in Picture 9, is introduced below.

(1) The coal ash is crushed, then grounded into slurry with water by the Mill, and stored in the Raw Materials Tanks.

(2) Quantitative cement, gypsum and foaming agent is measured and mixed with the ash slurry and then poured into the mould box.

(3) After static pre-curing, it is demoulded, turned over and then cut into various specification blocks, and finally transported into the Autoclave by the steam-curing car. The mould box is returned and reused after the demoulding process.

(4) After steaming and curing with high temperature and high pressure, the porous light-weight aerated concrete blocks are formed. The blocks are conveyed out of the Autoclave and packed, and the bottom board is returned and reused.

Picture 10. Workshop

Picture 11. Final Product

At present light-weight concrete block is one of the most widely used light-weight building materials since it has the following advantages.

(1) Light weight. Volume density is generally 500 ~ 900kg / m3, only 1/5 of ordinary concrete and 1/4 of clay brick. The weight of the buildings and overall cost can be reduced significantly.

(2) Fire resistance. The main raw materials are mostly inorganic materials, so it has good fire resistance and do not emit harmful gases in case of fire.

(3) Noise absorption. As a specific porous structure, it has certain absorption capacity.

(4) Insulation. Due to internal material with a large number of pores and micro-pores, it has good thermal insulation properties.

(5) Seismic resistance. Generally, its seismic performance is two levels higher than that of clay bricks in case of same building structure.

(6) Environmental protection. The manufacturing and transportation process involves no polluting source. And it can also protect arable land and save energy, making it a green building material.

(7) Durability. The strength is stable. After a year of atmospheric exposure, the strength of test specimens increases by 25%, and still remains stable after a decade.

(8) Economy. Its cost is 30% less than ordinary concrete block. And it can increase the usage area, thus improving the utilization of building area.

2.5 Emergency Ash Storage Yard

Considering the time to promote the coal ash products and uncertainty of the market, an emergency ash storage yard is still essential to ensure the normal production of the power plant.

According to the amount of 300,000 tons of ash from the power plant per year, the capacity of the emergency ash storage yard should reach 100 million cubic meters.

The ash yard is built with negative excavation method to form a pond. The composite geo-membrane is set on the surface of bottom and inside slope for the ash yard to prevent seepage into the underground water. The effect of composite geo-membrane should be equal to performance of 1.0×10^{-7}cm/s permeability coefficient or 1.5m thick clay soil.

In case of emergency, the coal ash in the Ash Storage Tank will be discharged into the ash yard by the pipeline at the bottom of the Tank. A wet discharging mode is adopted to avoid the effect of fugitive dust and cause no dust pollution. The waste water and wet ash can both be used as raw materials in the production of light-weight concrete blocks, to achieve non-secondary pollution.

Picture 12. Emergency ash storage yard

3. Investment Analysis

The investment of the project is estimated to be 15.4 million dollars, of which:

(1) 6.5 million for 3x 30,000 tons Ash Storage Tanks and ash transportation pipeline system.

(2) 0.8 million for coal ash sorting system.

(3) 2.3 million for coal ash grinding system.

(4) 4.6 million for light- weight concrete block manufacture system.

(5) 1.2 million for exploration, design, office building, electric facilities and other ancillary works.

(6) The cost for emergency ash storage yard is not included temporarily.

Appendix 6: Sites Technical Evaluation and Comparison

No.	Item	Article	Candidate Sites				
			Domunli (Site 0)	Akwidaa (Site 1)	Atwereboana (Site 2)	Dutch Komenda (Site 3)	Ekumfi (Site 4)
1	Site Conditions	Location	It is 112km at the west of Takoradi. The site is about 1km away from the seashore to the south, to the east distant Bonyere village 2km, and to the north about 2km there is an asphalt road.	It is 30km at the south-west of Takoradi,2km at the east of Akwideaa, less than 1.5km away from the village around site.	It is 12km at the south-west of Takoradi, more than 2km away from the village.	It is 38km at the east of Takoradi, 3.5km at the east of Komenda, 22km at the west of cape coast.	It is 78km at the west of Accra, 27km at the west Winneba, 9km at the south-west of Mumford, 50km at the east of Cape coast. It is more than 0.6km away from village.
		The relation with the City Planning	It is accord with the urban planning.	Turtle beach preservation.	Turtle beach preservation. It is occupied by BOST PETROLEUM.	Public beach resort.	It is accord with the urban planning.
		The land Use	The land, which belongs to VRA, was planned for the construction of a gas firing power plant. It is a primeval forest zone with an area of 1600 acres (equal to667.7 hectares).	The land can be used extends to the stream to the west, and to the hill to the east, the length is 3km. The width is 2km from the seashore to the north.	The land can be used is 2.4km from western lagoon to east, and 2km from southern seashore to north.	The land can be used is 2.0km from west to east, and 2km from southern seashore to north. It is occupied by one American company.	The land can be used is 2.0km from west to east, and 2km from southern seashore to north. The chief of surrounding tribe supports the project.
		The terrain	The site is located near a lagoon entrance, with large areas of coconut and palm	The site lies in hilly areas, the terrain is relatively flat. The site lies in hilly areas, the	Many palm trees are planted around the site, the terrain is relatively flat, and the elevation is	Many palm trees are planted around the site, the terrain is relatively flat, and the elevation is	The site is an undeveloped land with good vegetation on the surface. The site lies in

No.	Item	Article	Candidate Sites				
			Domunli (Site 0)	**Akwidaa (Site 1)**	**Atwereboana (Site 2)**	**Dutch Komenda (Site 3)**	**Ekumfi (Site 4)**
			trees around. It lies in sand dune areas, and the terrain is relatively flat without any rocks along the seashore. The elevation is 5m to 50m.	terrain is relatively flat, and the elevation is 3 ~ 10m.	8m ~ 15m.	5m ~ 10m.	hilly areas, the elevation is 3m ~ 20m. The rock is appeared.
		Geological Conditions	Pile foundation can be taken for such main buildings as main power house, turbine room, chimney, large-loaded auxiliary buildings (structures) and so on.	Pile foundation can be taken for such main buildings as main power house, turbine room, chimney,large	loaded auxiliary buildings (structures) and so on.	Pile foundation can be taken for such main buildings as main power house, turbine room, chimney,large	Moderate weathered granite can be taken as natural foundation bearing layers for buildings (structures).

No.	Item	Article	Candidate Sites				
			Domunli (Site 0)	Akwidaa (Site 1)	Atwereboana (Site 2)	Dutch Komenda (Site 3)	Ekumfi (Site 4)
		Hydrological Conditions	the extreme highest tide level which the Return period is 100 years is 2.6m near the sea area of sites.And the Extreme wave Height which the Return period is 50 years is 3.4m.the plant area may be affected by the flood of small tidal lagoon and the tidewater of Atlantic ocean.	the extreme highest tide level which the Return period is 100 years is 2.6m near the sea area of sites.And the Extreme wave Height which the Return period is 50 years is 3.4m.The site is not affected by the Atlantic Ocean tidewater which the Return period is 100 years, but the site may be affected by the local watershed water catchment from north and east.	the extreme highest tide level which the Return period is 100 years is 2.6m near the sea area of sites.And the Extreme wave Height which the Return period is 50 years is 3.4m. The site is not affected by the Atlantic ocean tidewater which the Return period is 100 years, the plant area may be affected by the local watershed water catchment from north and east , and the flood of small tidal lagoon.	the extreme highest tide level which the Return period is 100 years is 2.6m near the sea area of sites.And the Extreme wave Height which the Return period is 50 years is 3.4m. The site is not affected by the Atlantic ocean tidewater which the Return period is 100 years, but the site may be affected by the local watershed water catchment from the north.	the extreme highest tide level which the Return period is 100 years is 2.6m near the sea area of sites.And the Extreme wave Height which the Return period is 50 years is 3.4m. The site is not affected by the Atlantic ocean tidewater which the Return period is 100 years, , but the site may be affected by the local watershed water catchment from the north.
		Meteorological conditions	The country doesn't have obviously different four seasons but dry and rainy seasons. The rainy season is from May to October, while the dry season is from November to April of next year. The country's annual average atmospheric temperature is between 26℃ and 29℃. The dominant	The country doesn't have obviously different four seasons but dry and rainy seasons. The rainy season is from May to October, while the dry season is from November to April of next year. The country's annual	The country doesn't have obviously different four seasons but dry and rainy seasons. The rainy season is from May to October, while the dry season is from November to April of next year. The country's annual average atmospheric	The country doesn't have obviously different four seasons but dry and rainy seasons. The rainy season is from May to October, while the dry season is from November to April of next year. The country's annual average atmospheric temperature is between 26℃ and 29℃.	The country doesn't have obviously different four seasons but dry and rainy seasons. The rainy season is from May to October, while the dry season is from November to April of next year. The country's annual average atmospheric temperature is between 26℃ and

No.	**Item**	**Article**	**Candidate Sites**				
			Domunli (Site 0)	**Akwidaa (Site 1)**	**Atwereboana (Site 2)**	**Dutch Komenda (Site 3)**	**Ekumfi (Site 4)**
			wind direction is SW in all seasons through the year.	average atmospheric temperature is between 26℃ and 29℃. The dominant wind direction is SW in all seasons through the year.	temperature is between 26℃ and 29℃. The dominant wind direction is SW in all seasons through the year.	Tthe dominant wind direction is SW in all seasons through the year.	29℃. The dominant wind direction is SW in all seasons through the year.
		Plant Land and Demolishment	Plant land: $29x10^4m^2$. There is no demolishment inside the boundary of site	Plant land: $29x10^4m^2$. There is no demolishment inside the boundary of site	Plant land: $29x10^4m^2$. There is no demolishment inside the boundary of site	Plant land: 29 $x10^4m^2$. There is no demolishment inside the boundary of site	Plant land: $29x10^4m^2$. There is no demolishment inside the boundary of site
		Earthwork	Excavation: $50x10^4m^3$ Fill: $60x10^4m^3$	Excavation: $30x10^4m^3$ Fill: $40x10^4m^3$	Excavation: $30x10^4m^3$ Fill: $40x10^4m^3$	Excavation: $30x10^4m^3$ Fill: $40x10^4m^3$	Excavation: $250x10^4m^3$ Fill: $260x10^4m^3$
		Living Area	Layout near the plant by the sea	Layout near the plant by the sea	Layout near the plant by the sea	Layout near the plant by the sea	Layout near the plant by the sea
		Extension Conditions	Full	Full	Full	Full	Full
2	Trsnsportation	Highway transportation	Agona-Elubo RD is about 2km at the north of the site.	Takoradi-Agona RD (good road surface, 31km long), regional branch road (clay bound macadam pavement in poor condition, 6km long and 7m wide) and regional branch road	Takoradi-Agona RD is about 5km at the north of the site, one rural road about 2km at the east of the site connects Takoradi-Agona RD.	Cape Coast-Sekondi RD is about 5km at the north of the site	Accra-Cape Coast RD. is about 15km at the north of the site, the regional branch road I (clay bound macadam pavement in good condition, 5km long and 8m wide), regional branch road II

No.	Item	Article	Candidate Sites				
			Domunli (Site 0)	Akwidaa (Site 1)	Atwereboana (Site 2)	Dutch Komenda (Site 3)	Ekumfi (Site 4)
				(clay bound macadam pavement in poor condition, 3km long and 3.5m wide) successively locate around the site			(bituminous pavement in good condition, 10km long), and finally regional branch road III (clay bound macadam pavement in poor condition, 2.5km long and 3m wide) successively locate around the site.
		Access Road	The access roads will connect with Agona-Elubo RD.The length is 2km.	The access road will connect with A regional branch road. The length is 0.2km.	The access roads will connect with the regional branch road. The length is 2km. The rural road will be improved, the length is 5km.	The access road will connect with Cape Coast-Sekondi RD. The length is 2km.	The regional branch road III will be occupied by the plant area. The route must be changed to north of the plant, the length is 2.8km. The access road will connect with the changed road, the length is 0.3km.
3	Fuel Supply	Fuel Transportation	The fuel from South Africa will be transported to the plant coal terminal by sea.	The fuel from South Africa will be transported to the plant coal terminal by sea.	The fuel from South Africa will be transported to the plant coal terminal by sea.	The fuel from South Africa will be transported to the plant coal terminal by sea.	The fuel from South Africa will be transported to the plant coal terminal by sea.

No.	**Item**	**Article**	**Candidate Sites**				
			Domunli (Site 0)	**Akwidaa (Site 1)**	**Atwereboana (Site 2)**	**Dutch Komenda (Site 3)**	**Ekumfi (Site 4)**
		Coal terminal	Be located at the south of the plant area.	Be located at the south of the plant area.	Be located at the south of the plant area.	Be located at the south of the plant area.	Be located at the south of the plant area.
4	Water Supply	Water Source	Sea water, once through	Sea water, once through	Sea water, once through	Sea water, once through	Sea water, once through
5	Ash handling	Ash yard	The proposed ash disposal area is set east of the power plant, and the distance between them is 200m.The area of ash disposal area is $48.15\times10^4m^4$. It can form $205.8\times10^4m^3$ capacity which will be enough for 5 years storage requirement.	The proposed ash disposal area is set east of the power plant, and the distance between them is 200m.The area of ash disposal area is $48.15\times10^4m^4$. It can form $205.8\times10^4m^3$ capacity which will be enough for 5 years storage requirement.	The proposed ash disposal area is set east of the power plant, and the distance between them is 200m.The area of ash disposal area is $48.15\times10^4m^4$. It can form $205.8\times10^4m^3$ capacity which will be enough for 5 years storage requirement.	The proposed ash disposal area is set east of the power plant, and the distance between them is 200m.The area of ash disposal area is $48.4\times10^4m^4$. It can form $207\times10^4m^3$ capacity which will be enough for 5 years storage requirement.	The proposed ash disposal area is chose at a valley, northwest of the power plant, and the distance between them is 1km. The area of ash disposal area is $63\times10^4m^2$. It can form $208\times10^4m^3$ capacity which will be enough for 5 years storage requirement.

No.	Item	Article	Candidate Sites				
			Domunli (Site 0)	**Akwidaa (Site 1)**	**Atwereboana (Site 2)**	**Dutch Komenda (Site 3)**	**Ekumfi (Site 4)**
		Ash Conveying	The ash and slurry will be conveyed through road, the transportation distance is 0.3km.	The ash and slurry will be conveyed through road, the transportation distance is 0.3km.	The ash and slurry will be conveyed through road, the transportation distance is 0.3km.	The ash and slurry will be conveyed through road, the transportation distance is 0.3km.	The ash and slurry will be conveyed through road, the transportation distance is 1.2km.
6	Power evacuatio n	Voltage grade and line length	Two 330kV line will be build to the Aboadze substation at the east of Takordi, the length is 145km.	Two 330kV line will be build to the Aboadze substation at the east of Takordi, the length is 50km.	Two 330kV line will be build to the Aboadze substation at the east of Takordi, the length is 35km.	Two 330kV line will be build to exiting 330kV line at the north of the site, the length is 15km.	Two 330kV line will be build to exiting 330kV line at the north of the site, the length is 15km.
		Outgoing Corridor	Power evacuation is towards east, there is enough space.	Power evacuation is towards east	There is enough space.	Power evacuation is towards east	Power evacuation is towards south, then turns west and turn s north, there is enough space.
7	Enviro nmenta l Protecti	The influence	The discharge can meet the requirements	The discharge can meet the requirements	The discharge can meet the requirements	The discharge can meet the requirements	The discharge can meet the requirements
8	Construction Conditions	Construction area	Layout at the north of the plant, the land area is $15x10^4m^2$.	Layout at the north of the plant, the land area is $15x10^4m^2$.	Layout at the north of the plant, the land area is $15x10^4m^2$.	Layout at the north of the plant, the land area is $15x10^4m^2$.	Layout at the east of the plant, the land area is $15x10^4m^2$.

No.	Item	Article	Candidate Sites				
			Domunli (Site 0)	Akwidaa (Site 1)	Atwereboana (Site 2)	Dutch Komenda (Site 3)	Ekumfi (Site 4)
		Living area for Constructor	Layout at the west of the freight road, the land area is $4x10^4m^2$.	Layout at the west of the plant, the land area is $4x10^4m^2$.	Layout at the north of the access road, the land area is $4x10^4m^2$.	Layout at the west of the freight road, the land area is $4x10^4m^2$.	Layout at the west of the plant, the land area is $4x10^4m^2$.
		Heavy equipment transportation	Shipping	Shipping	Shipping	Shipping	Shippingg
9	Comprehensive Evaluation		Advantages: (1) VRA has acquired land of 1600 acres. (2) Access road is short, only 2km. (3) The sea is not occupied. (4) A small of earthworks Disadvantages: (1) The site is remote, peripheral infrastructures and supports condition poor. (2) 330kV transmission line is longer. (3) The foundation adopts	Advantages: (1) The sea is not occupied. (2) A small of earthworks (3) The site is relatively flat, and the natural level is proper for the plant layout. (4) Nice water depth. Disadvantages: (1) 330kV transmission line is longer. (2) The foundation adopts piles.	Advantages: (1) The sea is not occupied. (2) A small of earthworks (3) The site is relatively flat, and the natural level is proper for the plant layout. Disadvantages: (1) 330kV transmission line is longer. (2) The foundation adopts piles. (3) Water intake pipes are longer.	Advantages: (1) The sea is not occupied. (2) A small of earthworks (3) 330kV transmission line is longer. (4) The site is flat, and the level is proper for the plant. (5) Access road to be broaden and paved is short, about 4km. Disadvantages: (1) The foundation adopts piles. (2) Water intake pipes are	Advantages: (1) The chief of surrounding tribe support the project. (2) The ground is stable with high bearing strength, no pile foundation expected so far. (3) Access road to be broaden and paved is short, about 4km. (4) Good peripheral infrastructure and supporting condition. Not obvious siltation issues. (5) 330kV transmission

No.	Item	Article	Candidate Sites				
			Domunli (Site 0)	Akwidaa (Site 1)	Atwereboana (Site 2)	Dutch Komenda (Site 3)	Ekumfi (Site 4)
			piles. (4) Water intake pipes are longer. (5) The coal conveying gallery is longer.	(3) Water intake pipes are longer. (4) The access road condition is bad, 10km access way need to be broaden and paved. (5) The seashore is turtle beach preservation (6) The coal conveying gallery is longer.	(4) Land acquisition issues, It may be acquired by BOST PETROLIUM. (5) Environmental Issues, maybe turtle beach preservation. (6) The coal conveying gallery is longer.	longer. (3) The coal convey gallery is longer. (4) Land acquisition issues, the site may be acquired by others.	line is shorter. (6) Water intake pipes are shorter. (7) The coal conveying gallery is shorter. Disadvantages: (1) A large of earthworks (2) The sea will be occupied. (3) The rural will be changed.

Appendix 7: Background Information Document for Scoping Consultation

Background Information

1. The Shenzhen Energy Group (SEC) in collaboration with Volta River Authority (VRA), intends to develop a supercritical coal-fired generating facility within the coastal region of Ghana.

2. The overall installed capacity of the generating plant is proposed to be 2,000MW in total for the coal-fired power plant project.

3. The project is planned to be developed in two phases; Phase 1 would be 2 × 350MW supercritical generating units construction, and Phase 2 is planned for 2 x 600 MW supercritical generating units construction.

4. Phase I project is planned to be commenced in August 2016 and the 2×350MW units will be completed and put into commercial operation from 2019.

5. The project main components comprises:
   5.1 Super-critical coal generation plant
   5.2 Coal handling Terminal
   5.3 Power transmission line (ROW)

6. It is preliminarily considered to use thermal coal from South African with Net Calorific Value not less than 5,500kcal/kg as the coal source.

7. The coal is shipped from the South African Richards bay and then transport to the affiliated 100,000 DWT coal handling terminal of the power plant. Backup coal source can be available from Columbia or other countries.

8. Environmental standards would comply to EPA guideline for the local requirements of Ghana; flue gas emission shall also meet the relevant IFC and World Bank Group standards.

9. It is proposed to adopt seawater once-through circulation water system for the Project; the circulating water is taken from the basin of coal handling terminal.

10. The fresh water of the power plant is initially supposed to obtain through seawater desalination system; however local sources are being considered.

Project Activities

Construction Phase
Transportation, Drilling, Blasting, Installation and Construction works would account for the vast majority of the activities and consequently the related impact on the atmosphere environment.

Operational Phase
Operation of the plant including uptake and discharge of sea water, arrival and dispatch of vessels carrying coal and evacuation of electric power.

Environmental and Social Impact Assessment

Environmental and Social Impact Assessment Report for the development of a 2 X 350MW Coal-fired generating plant and associated facilities would be prepared

The detailed ESIA study to determine the impact of the project on the environment, workers and society and to propose environmental, health and safety impact mitigation measures for the pre-construction, construction/demobilization, operational and decommissioning phases, taken into consideration, review comments from the EPA, other stakeholder agencies and the general public especially the community.

Stakeholder Comment Sheet

We solicit your response to the following questions to inform of your concerns and appreciation of the project.

1. What are the primary concerns and or benefits the project is likely to cause to you and the community; particularly relating to environmental, economic and social aspects?

2. In your opinion, what are the positive and negative aspects of the proposed project?

3. Do you have or know of any information that might be relevant to the EIA (e.g. environmental information and community, social or economic information).

Appendix 8: Consultation Records

Attendance List of the Stakeholders Forum on April 13, 2015

PROPOSED COAL-FIRED POWER PLANT BY VRA & SHENZHEN ENERGY GROUP

STAKEHOLDERS FORUM- April 13, 2015

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PROPOSED COAL-FIRED POWER PLANT BY VRA & SHENZHEN ENERGY GROUP

STAKEHOLDERS FORUM- April 13, 2015

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PROPOSED COAL-FIRED POWER PLANT BY VRA & SHENZHEN ENERGY GROUP

STAKEHOLDERS FORUM- April 13, 2015

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PROPOSED COAL-FIRED POWER PLANT BY VRA & SHENZHEN ENERGY GROUP

STAKEHOLDERS FORUM- April 13, 2015

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PROPOSED COAL-FIRED POWER PLANT BY VRA & SHENZHEN ENERGY GROUP

STAKEHOLDERS FORUM- April 13, 2015

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Peter Osei-Adjei	VRA	peter.osei-adjei@vra.com
Martin Adjei	VRA	martin.adjei.vra.com
Stephen Ofori.	VRA	stephen.ofori@vra.com
Andriana Nelson	EPA	andriana.nelson@epa.gov.gh

Media Registration Form

VOLTA RIVER AUTHORITY
MEDIA REGISTRATION FORM
CLEAN COAL POWER PRESENTATION VENUE;
CLEAVER HOUSE, ACCRA WEDNESDAY, MAY 11, 2016

NAME	MEDIA HOUSE	SIGNATURE	CONTACT NUMBER
Rabiu Alhassan	TV3	[illegible]	0242 548 562
Tano Richmond			
Ebenezer Quaye Micheal Oti	METRO TV	[illegible]	0277 724 236. 0241525278

NAME	MEDIA HOUSE	SIGNATURE	CONTACT NUMBER
Kenneth Adade	The Finder	[illegible]	0242224535
EMML QVAME	DORLY	[illegible]	0277 611175
MARY MENSAH	GRAPHIC	[illegible]	0244069070
CEPHAS LARBI	DAILY GUIDE	[illegible]	0545233283
Kodjo Adams	GNA	[illegible]	0244073057

NAME	MEDIA HOUSE	SIGNATURE	CONTACT NUMBER
Henry Mawtirsan	Radio Gold		0244198158
Araba Agyrey	Adom FM		0241511231
Eugenia Asamadu-Sakyi	GBC Radio		0242715792
Naa Ayele Aryeetey Atsu Tsikata Bernard Hanzie Richard Acquah	TV Africa		0275120642

NAME	MEDIA HOUSE	SIGNATURE	CONTACT NUMBER
Kojo Backal	Radio XYZ		0267714979
Evans K. Yeboah	Oman Fm		0275660811
Daniel Raymond Adjei	The Punch Newspaper		0574488129
Ben Hayes	Daily Searchlight		0277723255
Ellen Agbanor	Ghanaian Observer		0276020255

NAME	MEDIA HOUSE	SIGNATURE	CONTACT NUMBER
Dominic Andoh	BFT	[signature]	0243376878
Godfred Dorvmelapor	UTV	[signature]	0277081292
Prince Ahenkan	UTV	[signature]	0248686646
Samuel Effah	UTV	[signature]	0243925246
Julius Yao Petetsi	Ghanaian Times	[signature]	0244460708

NAME	MEDIA HSE	SIGNATURE	CONTACT	E-mail
Rachel Quartey Edem Hormeku Fred Sogbo Joseph Sarkyi	GTV news GBC 24	[signature]	0278139229 0244279426 0243910914 0208216638	rachelnkg71@gmail.com edem2ost@yahoo.com fredsogbo@yahoo.com
Jonai Kwasi Ampofo	Kessben TV & Agro Fm	[signature]	0242049518	kwasi44@yahoo.com
Ben Kuma	freelance	[signature]	0245404600	bennykermeh@yah
Domey Freeman Blay	Oneta Films	[signature]	0541066[illegible]	domeyfreeman@gmail.com

Reply from Energy Commission

ENERGY COMMISSION

Ghana Airways Avenue, Airport Residential Area (behind Alliance Française)

Private Mail Bag
Ministries Post Office
Accra - Ghana

Tel: 0302 813756/7
Fax: 0302 813764
IDD Code: (233-302)
E-mail: info@energycom.gov.gh
Website: http://www.energycom.gov.g

EC/TRD/PWR/15/EMO/017

4th January, 2015

The Deputy General Managing,
Sunon Asogli Power (Ghana) Limited,
PMB 267,
Comm 1,
Tema.

Dear Sir,

RE: REQUEST FOR INFORMATION FOR THE CONSTRUCTION OF COAL FIRED POWER PLANT

We refer to your letter dated 25th February, 2015 on the above subject.

The Commission has no objection to your decision of building a coal-fired power plant in the country. However, we expect that you use the best technology in your operations to limit any pollution that may come along with the proposed plants.

The Commission wish to indicate that you require a Wholesale Electricity Supply Licence to generate power in Ghana. In that regard, you are to complete an application form and submit with exhibits as part of the application process. You are also to pay an application fee of thirty thousand three hundred Ghana Cedis (Gh¢ 30,300.00) for a Provisional Wholesale Electricity Supply Licence.

The procedures for the acquisition of a licence are spelt out in the Licence Application Manual for service providers in the Electricity Supply Industry which is available on the Commissions website at www.energycom.gov.gh or can be purchased at the office of the Commission for an amount of Forty Ghana Cedis (GH¢ 40.00)

Thanks.

Yours faithfully,

Mr. Micheal Opam
Ag. Executive Secretary

SUNON ASOGLI POWER (GH) LTD.
DOCUMENT
DATE: 9-03-15
RECEIVED
ADMINISTRATION DEPT.

Appendix 9: Scoping Notice

深圳能源 SHENZHEN ENERGY

SCOPING NOTICE

VOLTA RIVER AUTHORITY

The Shenzhen Energy Group Co., Ltd. of China (SEC) in collaboration with the Volta River Authority (VRA) intends to develop a 2×350MW supercritical coal-fired generating units (including affiliated coal handling terminal), at Ekumfi within the coastal areas of the Ekumfi District in the Central Region of Ghana. This project is known as the "***2 x 350MW Supercritical Coal Fired Power Plant***" and represents the first phase of the development which is to be further expanded either by a 4×350MW (or 2×600MW) supercritical coal-fired generating units.

Notice of the proposed "***2 x 350MW Supercritical Coal Fired Power Plant***"" is hereby served for public information, as required under the procedures for the conduct of EIA in accordance with Regulation 15(1) of LI. 1652.

Any person(s) who have an interest, concern, or special knowledge relating to potential environmental effects of the proposed undertaking may contact or submit such concerns, etc., to:

The Chief Executive Officer
Volta River Authority
P. O. Box MB 77, Accra
Tel No: +233-302-664941-9
Fax: +233-30-2662610
Email: corpcomm@vra.com

AND

The Executive Director
Environmental Protection Agency
P. O. Box M 326, Accra
Tel No: +233-302-664697/8
Fax No: +233-302-662690
Email: info@epa.gov.gh

Or

The Deputy Manager,
Shenzhen Energy Ghana
Coal Fired Pre-project Office
Private Mail Bag 267,
Community 1 Post Office
Tema, Ghana
Tel: +233 544343449

Not later than 31st January, 2016

Appendix 10: Profile of ESIA Team

The Specialist team conducting the environmental and social impact assessment for the 2x350MW Supercritical Coal-Fired Power Plant is a consortium comprising Premier Resource Consulting, ESL Consulting and Envaserve Research Consult. The team members have over fifteen years of experience in Environmental Technology and Management as well as sector specialist knowledge.

The specialists and expected roles on the team are presented below:

SPECIALISTS	NAME	ROLE
ESIA and Environmental Technology Specialist	Mr. Felix Quansar (ESIA LEAD CONSULTANT)	Coordination of the entire study Baseline assessment Environmental Technology Transfer Process Analysis Environmental Impact Analysis Safety and Risk Design Public Consultation Drafting Reports and Quality Assurance
Subtidal and Intertidal Ecology	Lead: Mr. Ayaa Kojo Armah (ESIA ASSISTANT LEAD CONSULTANT) Assistant: Amanor Kisseih	Assist Coordination of Entire Study and Quality Control Coordinator for Ecological Survey & Habitat Assessment Study Loss and disturbance to subtidal benthos
Modeling Specialist	Lead: Mr. Emmanuel Lamptey Assistant Selorm Dzako Ababio	Air quality monitoring Emission Monitoring Noise Monitoring Conducting Air Emission Dispersion, Noise and Seawater modeling Green House Gas Emission and Climate Change assessment
Assistant Ecology Review Coordinator	Anthony Bentil	Will assist Project manager in all activities which include project planning, baseline surveys, environmental and social impacts identification, analysis and mitigation. Will be involved in stakeholder consultations and report writing.
Marine Mammals and Turtles	Lead: Mr. Andy Agyekumhene Assistant: Enoch Armah	Potential impacts on marine mammals, including endangered and vulnerable species that are thought to be present in the local area and known to be present in the wider area; Potential impacts on sea turtle species that may nest in the area of works and migrate across the area; rapid sea turtle field verification survey
Vegetation/Forest Ecologist	Lead: Dr. James K. Adomako	List the prominent plant species (trees, shrubs, grasses and other herbaceous species of special

SPECIALISTS	**NAME**	**ROLE**
	Assistant: John Amponsah	interest) present for vegetation unit and ecosystem delimitation. Identify plant species of conservation importance; which could possibly occur at the site. Make recommendation on suitability of site for the project regarding the extent of impacts on the ecology
Marine, Fresh Surface and Ground Water Quality Related Impacts/ Marine Sedimens	Lead: Dr. Ansa-Asare Assistant: Victor Mante	pH and Temperature Salinity and Conductivity Biological and Chemical Oxygen Demand Turbidity Dissolved and Suspended Solids Hydrocarbons Oil and Grease Heavy Metals Nutrients Microbiology Grain size analysis
Fisheries	Lead: Richmond Quartey Assistant: Emmanuel Klubi	Potential impacts on fish nursery and spawning grounds Plankton and benthos assessment
Animal Ecologist (Terrestrial)	Lead: Charles Christian Amankwah Assistant: Francis Seku	Identify animal/faunal species of conservation importance; which could possibly occur at the site Make recommendation on suitability of site for the project regarding the extent of impacts on the ecology
Sociologist/Stakeholde r Consultation	Lead: Adu-Nyarko Andorful Assistant: Bright Yeboah	Possess extensive experience in the six coastal districts with local communities and other stakeholders. Will lead all stakeholder consultations Socio-economist/rap expert
Terrestrial Soil and Geology Investigation	Lead: Dr. D. F. K Allotey Assistant: Moses Ocquaye	Site soil contamination and qualification assessment including physicochemical analysis, pH, Sulphate, Chloride, Poly Aromatic Hydrocarbon (PAH) and Total Petroleum and Hydrocarbon (TPH)
Valuation	Lead: Yaw Osei-Wusu Peprah Assistant: George Nimako	Land acquisition processes Valuation Drafting Property impact Report
Landscape and Seascape Specialist	Maxwell Mensah Clottey	Landscape, Seascape and Visual Impact Assessment
Historical Resource Specialist	Maxwell Mensah Clottey	Historical resource and cultural heritage assessment

15 INDEPENDENT REPORTS

Independent Report 1: Ecological Survey and Habitat Assessment Study

Independent Report 2: Socio-economic Impact Assessment

Independent Report 3: Landscape, Seascape and Visual Impact Assessment

Independent Report 4: Historical Resources and Cultural Heritage Assessment

Independent Report 5: Air Emission Dispersion Modelling Report

Independent Report 6: Noise Dispersion Modelling Report

Independent Report 7: Thermal Plume Modelling Report