TECHO-ECONOMIC FEASIBILITY STUDY

Embedded 10MWh Integrated Gasification Power Plant for XENERGI LTD in Enpower Free Trade Zone, 9th Mile Corner, Enugu, Enugu State, Nigeria

EMBEDDED
10 MWH INTEGRATED GASIFICATION
POWER PLANT

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10 MWH INTEGRATED GASIFICATION POWER PLANT FOR THE ENPOWER FREE TRADE ZONE 9th Mile Corner, Enugu State, Nigeria

EMBEDDED POWER GENERATION PROJECT

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DISCLAIMER

The purpose and scope of this Technoeconomic Feasibility Study Report is to introduce the subject matter and provide a general idea and information on the said project. All the materials included in this document is based on data/information gathered by MDACI from the Nigerian Electricity Regulatory Commission (NERC), the federal ministry of Power (FMP), the Federal Ministry of Mines and Steel Development (FMMSD), the Federal Ministry of Environment (FMENV), the Project Company (XENERGI LTD) and operators within the energy and power industry, market surveys and analysis, the project promoter and various other sources and is based on certain assumptions. Although, due care and diligence has been taken to compile this document, the contained information may vary due to any change in any of the concerned factors, and the actual results may differ substantially from the presented information. ***MDACI*** *does not assume any liability for any financial or other loss resulting from this feasibility report in consequence of undertaking this activity due to any changes in the factors forming the basis of the projections put forward in this report.*

GLOSARY AND DEFINITIONS OF TERMS

AACE: Association for the Advancement of Cost Engineering

ANSI: American National Standards Institute

ASU: Air separation unit

Boiler System: A boiler is a closed vessel in which water or other fluid is heated under pressure. The steam or hot fluid is then circulated out of the boiler for use in various process or heating applications. A valve is required to prevent over pressurization and possible of a boiler.

BTU: British Thermal Unit – Unit of heat equal to the amount of heat required to raise one pound of water one degree Fahrenheit at one atmosphere pressure; equivalent to 251.997 calories

Btu/h: British thermal unit per hour

Btu/kWh: British thermal unit per kilowatt-hour

Btu/lb: British thermal unit per pound

CCECC: China Civil Engineering Construction Corporation

CDR: Carbon Dioxide Recovery

CEMS: Continuous Emission Monitoring System

CLC: Closed Loop Control

CS: Consultancy Services

dB: Decibel

DC: Direct Current

DCS: Distributed Control System

DIN: Deutsches Institut für Normung e. V. Representative of German interests in supranational standardization

DNV: Det Norske Veritas

ECPA: Excess Crude Proceeds Account

EIA: Environmental Impact Assessment

EIS: Environmental Impact Statement

EPA: Environmental Protection Agency

EPCI: Engineering, Procurement, Construction and Installation

EPPs: Emergency Power Producers

EPSR: Nigeria's Electric Power Sector Reform

EU: European Union

FD: Forced draft

FEPA: Federal Environmental Protection Agency

FG: Federal Government

FGD: Flue gas desulfurization

FGN: Federal Government of Nigeria

FMMSD: Federal Ministry of Mines and Steel Development

FMP: Federal ministry of Power,

FRN: Federal Republic of Nigeria

FTZ: Free Trade Zone

GQA: General Quality Assessment

gpm: Gallons per minute

Invested capital means the capital required to implement an investment project, including legal capital and loan capital

HHV: Higher heating value

HP: High Pressure

H_2SO_4: Sulfuric acid

HV: High Voltage

I&C: Instrument and Control

ID: Induced draft

ICC: International Chamber of Commerce

IEC: International Electrotechnical Commission

IEEE: Institute of Electrical and Electronics Engineers

IG: Integrated gasification

IGCC: stands for Integrated Gasification Combined Cycle. It is a technology using a high-pressure gasifier to turn coal and other carbon-based fuels into pressurized gas – synthesis gas (syngas). It can then remove impurities from the syngas prior to the power generation cycle. Some of these pollutants, such as sulphur, can be turned into re-usable by-products through the Claus process. This results in lower emissions of sulphur dioxide, particulates, mercury, and in some cases carbon dioxide. With additional process equipment, a water-gas shift reaction can increase gasification efficiency and reduce carbon monoxide emissions by converting it to carbon dioxide. The resulting carbon dioxide from the shift reaction can be separated, compressed, and stored through sequestration. **Excess heat from the primary combustion and syngas fired generation** is then passed to a **steam cycle**, **similar to a combined cycle** gas turbine. This process results in improved thermodynamic efficiency compared to conventional pulverized coal combustion.

IMF: International Monetary Fund

INCOTERMS: International Commercial Terms (established by the International Chamber of Commerce to define international terms regulating the delivery of technology and work).

IOU: Investor Owned Utility

IP: Intermediate Pressure

IPP: Independent Power Producer

IRR: Internal Rate of Return

ISO: International Organization for Standardization

JV: Joint-Venture

kg/GJ: Kilogram per gigajoule

kg/h: Kilogram per hour

kJ: Kilojoules

kJ/h: Kilojoules per hour

kJ/kg: Kilojoules per kilogram

kPa: Kilopascal absolute

kV: Kilo Voltage

kW: Kilowatt

kWe: Kilowatts electric

kWh: Kilowatt-hour
lb: Pound

lb/h: Pounds per hour

lb/ft^2: Pounds per square foot

lb/MMBtu: Pounds per million British thermal units

lb/MWh: Pounds per megawatt hour

L/C: Letter of Credit

LCOE: Levelized Cost of Electricity

LNG: Liquefied Natural Gas

LP: Low Pressure

LR: Lloyds Register of Shipping

lpm: Litres per minute

m: Meters

LV: Low Voltage

MEA: monoethanolamine

MDGs: Millennium Development Goals

MSMD: Ministry of Solid Minerals Development

MV: Medium Voltage

MW: Megawatt

MWe: Megawatt energy (similar to MWh to designate the Plant Capacity)

MWh: Megawatt hour (used to designate the Plant Capacity)

M&SD: Mines & Steel Development Department

MTD: Metric Ton per Day

MTFS: medium-term fiscal strategy

MTY: Metric Ton per Year

MYTO: Multi-Year Tariff Order

NCC: Nigerian Coal Corporation

NDT: Non-Destructive Test

NEEDS: National Economic Empowerment and Development Strategy

NEPA: National Electricity Power Authority

NERC: Nigerian Electricity Regulatory Commission

NESREA: National Environmental Standards and Regulations Enforcement Agency

NIBOR: Nigerian Interbank Offered Rate

NIPC: Nigeria's Investment Promotion Commission

NITEL: Nigerian Telecommunication

NKK: Nippon Kaiji Kyokai

NMC: Nigerian Mining Company

NOH: Number of Operating Hours

NOx: Nitrogen Oxide

NSE: Nigerian Stock Exchange

OLC: Open Loop Control

O&M: Operations and Maintenance

OPIVWO: Over pressure/valve wide open

PAM: Project Administration Manual

PM: Particulate Matter (also called particle pollution): the term for a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye.

PHCN: Power Holding Company of Nigeria Plc

PPP: public-private partnerships

PPR: Private Public Partnership

PPR: Projects Performance Report

PPS: polyphenylensulfide

PSI: A unit of pressure, pounds per square inch

psia: Pounds per square inch absolute

psid: Pounds per square inch differential

psig: Pounds per square inch gage

PTFE: Teflon (Polytetrafluoroethylene)

QC: Qualifying Certificate

Semi-detached House: One of two dwellings, attached by a common wall that is located within one building.

SEC: Securities and Exchange Commission

SNCR: Selective non-catalytic reduction

SO_2: Sulphur dioxide

SOE: State Owned Enterprises

TCC: Total Consultancy Cost

TCN: Transmission Company of Nigeria (operating under PHCN)

TCPC: Technical Committee on Privatization and Commercialization

TNC: Transnational Corporation

ton: Metric Ton (1,000kg)

TPC: Total Project/Plant Cost

TPD: Tons per day

TPH: Tons per hour

TS: Technical Support or Technical Specification

US$/US$: United States Dollar (Currency of the United States of America)

V: Voltage

V-L: Vapor Liquid portion of stream (excluding solids)

vol%: Volume percent

VOC: Volatile Organic Compounds

WASGP: West African Gas Project

wt%: Weight percent

CHAPTER I: PROJECT NATURE AND PURPOSE

1. INTRODUCTION

1.1 Implementation location of the project

The proposed (**3 x 3.333 MWh / TGC 2032 V12**) **10 MWh** Integrated Gasification (IG) power project (stage 1) shall be implemented on an area of **1.6 ha (16,000 m^2)** in the Enpower Free Trade Zone (EFTZ), which is located in **Enugu State**, a mainland state in south-eastern Nigeria. EFTZ is also known as Enugu Free Trade Zone, being the only existing free trade zone in the state. Its capital is **Enugu**, from which the state, created in 1991 from the old Anambra State, derives its name. The principal cities in the state are Enugu, Agbani, Awgu, Udi, Oji-River, and Nsukka. Enugu's 2021 population is now estimated at 795,271, which the population of Nigeria is 212,389,018 (the largest population in Africa). This **excess heat generated from this primary combustion and syngas fired generation (herein called Integrated Gasification Simple Cycle – IGSC)** is then passed to a **steam cycle**, **similar to a combined cycle** gas turbine, to form an **Integrated Gasification Combine Cycle – IGCC**. This process results in improved thermodynamic efficiency compared to conventional pulverized coal combustion. For the purpose the addition size of steam Turbine is the selected Siemens Steam Turbine, the standard **single-stage Steam Turbine (D-R SST 350 / 500 / 700)** of a total power output of **3.500MWh**. The Total installed capacity of stage 1 will be increased to **13,499 MWh** (stage 2). This Study report consist of the bankable development of both cases (stage 1 and stage, which can be built at once or subsequently) with the provision of a future expansion up to 60MWh on a maximum land area of 10ha as shown on the construction site layout of the project detailed technical designs.

Solid fuels gasification technology has been understood and applied for a very long time. The current directions in developing coal gasification technology are primarily related to power generation in combined systems involving steam and gas turbine or genset implementation, which considerably increases fuel use efficiency. Compared to the first gasifying installations, the current solutions have a much higher conversion intensity and are more reliable. Integrated power generation-related gasification technology developments have created increased interest in chemical products, such as **liquid motor fuels, methanol and hydrogen**. At the present time, the basic reason for the increase of coal use as a raw material for chemical production is the dynamic industrial growth in countries with high economic potential that do not have their own natural gas and oil resources and have limited access to international sources of the above minerals, Enugu State, called the Coal State of Nigeria, has huge coal reserve of unexploited coal, causing environmental problems in the communities. Coal mines at sites in Onyeama, Iva Valley, Ogbete, and Okpara, now abandoned, still cause environmental, public health injustices as locals combat efforts to sell the properties for more mining and coal power processing. This justifies the use of Integrated Gasification combined Cycle (IGCC), which one of the most environmentally friendly coal-to-power generation process to develop and protect the environment and simultaneously solve the Nigeria power supply crisis and the local communities burdens.

1.1.1 Geography

Enugu State is one of the states in the eastern part of Nigeria. The state shares borders with Abia State and Imo State to the south, Ebonyi State to the east, Benue State to the northeast, Kogi State to the northwest and Anambra State to the west.

Enugu, the capital city of Enugu State, is approximately 2½ driving hours away from Port Harcourt, where coal shipments exited Nigeria. Enugu is also located within an hour's drive from Onitsha, one of the biggest commercial cities in Africa and 2 hours drive from Aba, another very large commercial city, both of which are trading centres in Nigeria. The average temperature in this city is cooler to mild (60 ºF) in its cooler months and gets warmer to hot in its warmer months (upper 80 ºF) and very good for outdoor activities with family and friends or just for personal leisure.

Enugu has good soil-land and climatic conditions all year round, sitting at about 223 metres (732 ft) above sea level, and the soil is well drained during its rainy seasons. The mean temperature in Enugu State in the hottest month of February is about 87.16 °F (30.64 °C), while the lowest temperatures occur in the month of November, reaching 60.54 °F (15.86 °C). The lowest rainfall of about 0.16 cubic centimetres (0.0098 cu in) is normal in February, while the highest is about 35.7 cubic centimetres (2.18 cu in) in July.

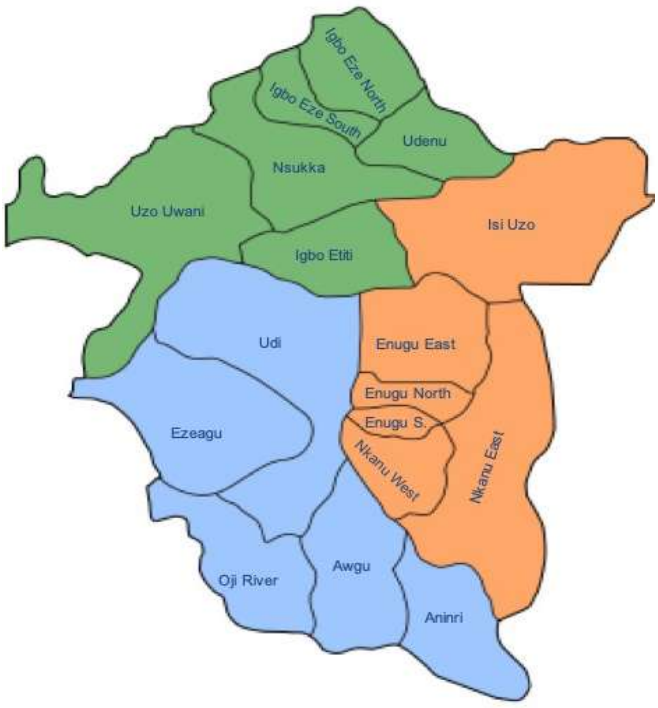

Fig. 1 – Map of Enugu State showing the 17 Local Government Areas (LGAs).

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1.1.2 History

The name of State derives from its capital city, Enugu. The word "Enugu" (from *Enu Ugwu*) means "the top of the hill". The first European settlers arrived in the area in 1909, led by a British mining engineer, Albert Kitson. In his quest for silver, he discovered coal in the Udi Ridge. Colonial Governor of Nigeria Frederick Lugard took keen interest in the discovery, and by 1914 the first shipment of coal was made to Britain. As mining activities increased in the area, a permanent cosmopolitan settlement emerged, supported by a railway system. Enugu acquired township status in 1917 and became strategic to British interests. Foreign businesses began to move into Enugu, the most notable of which were John Holt, Kingsway Stores, British Bank of West Africa and United Africa Company. From Enugu the British administration was able to spread its influence over the Southern Province of Nigeria. The colonial past of Enugu is today evidenced by the Georgian building types and meandering narrow roads within the residential area originally reserved for the whites, an area which is today called the Government Reserved Area (GRA).

From being the capital of the Southern Provinces, Enugu became the capital of the Eastern Region (now divided into nine States), the capital of now defunct Federal Republic of Biafra, thereafter, the capital of East Central State, Anambra State, (old) Enugu State, and now the capital of the present Enugu State through a process of state creation and diffusion of administrative authority.

1.1.3 Politics

The State Government and the Local Government are the two levels of government in Enugu State and in all other states of Nigeria. Sullivan Chime is the current executive governor for the whole of Enugu State. He was elected by the people of Enugu State in April 20071 and was sworn into office on May 29, 2007.2 The governor is above a group of commissioners who he has placed as heads of ministries that oversee various portfolios such as Health and Housing; both the governor and the commissioners form the Executive Council of Enugu State. Government House, Enugu is where the government of the state is based.

The 17 Local Government Areas in Enugu State3: Aninri, Awgu, Enugu East, Enugu North, Enugu South, Ezeagu, Igbo Etiti, Igbo Eze North, Igbo Eze South, Isi Uzo, Nkanu East, Nkanu West, Nsukka, Oji River, Udenu, Udi, and Uzo Uwani.

1 *The Daily Sun* (Sun News) December 14, 2007
2 Daily Independent. May 4, 2010. Retrieved 2010-09-03
3 Nigerian National Bureau of Statistics (NNBS)

1.1.4 Economy

Economically, the state is predominantly rural and agrarian, with a substantial proportion of its working population engaged in farming, although trading (18.8%) and services (12.9%) are also important. In the urban areas trading is the dominant occupation, followed by services. A small proportion of the population is also engaged in manufacturing activities, with the most pronounced among them located in Enugu, Oji, Ohebedim and Nsukka. The state boasts of a number of markets especially at each of the divisional headquarters, prominent of which is the Ogbete Main market in the State capital, Enugu. There is also one of the largest grains market East of the Niger, the Orie Orba Market which plays host to most farmers from the North Central States of Benue, Kogi, Nassarawa and Plateau who use the market to dispose their produce for consumers in South-East and South-Southern Nigeria. Every four days, grains and other farm produce are found in large quantities and at highly competitive prices.

Energy

Electricity supply is relatively stable in Enugu and its Environs. The Oji River Power Station (which used to supply electricity to all of Eastern Nigeria) is located in Enugu State. With the deregulation of electricity generation in Nigeria, and the privatisation of the Power Holding Company of Nigeria (PHCN), it is hoped the State Government would assist private investors to negotiate the take over and reactivation of the Oji Power Station. **This is more so with the proximity of the Enugu coal mines to the power station, a driving distance of about 20 minutes**. There are also traces of crude oil in Ugwuoba, in the same Oji-River Local Government area of the state. The state will also negotiate with investors interested in investing in the coal mining in Enugu. The coal industry used to be one of the biggest employer of labour in the state and the state is looking to attract investors in the industry.

Education

Every community in Enugu State has at least one Primary/Elementary school and one Secondary school, funded and run by the State Government. There are also large numbers of private nursery, primary and secondary schools in Enugu State. Nigeria's first indigenous university, (University of Nigeria, Nsukka (UNN)), is located in Enugu State. The state also hosts the Enugu State University of Science & Technology (ESUT), Institute of Management and Technology (IMT), Federal Cooperative College, Oji River (FCCO), Enugu State College of Education Technical, Enugu, Caritas University, Amorji-Nike, Renaissance University, Ugbawka; Federal Government College Enugu, Federal School of Dental Technology & Therapy College of Immaculate Conception, Enugu; Queen's School Enugu a Prominent high school for girls in the Eastern region; St. Theresa's College, Nsukka; Special Science Boys' Secondary School Agbani, Nkanu West l.g.a; [St. Patrick's Secondary School], Emene; Bigard Memorial Seminary, Enugu; Awgu County College, Nenwe; Community Secondary School, Ugbo-Okpala, Ugbo; Corpus Christi College, Achi, [Royal Crown Academy, Nsukka, Enugu State, Enugu]; Our Saviour Institute of Science and Technology, Enugu; and the Federal College of Education, Eha-Amufu, Seat of Wisdom Secondary School Trans Ekulu Enugu. There are also a host of private computer schools and training centres concentrated in Enugu and Nsukka.

Medicine

The University of Nigeria Teaching Hospital (UNTH) is located in Enugu State, as is the Enugu State University Teaching Hospital and College of Medicine. In addition to numerous private hospitals and clinics in the State, there are seven District Hospitals at Enugu Urban, Udi, Agbani, Awgu, Ikem, Enugu-Ezike, and Nsukka and at least one health centre or cottage hospital in every one of the seventeen (17) Local Government Areas and thirty-nine (39) Development Centres in the State.

2. FEDERAL AND STATE GOVERNMENTS ON POWER SECTOR

The vision of the Federal and State Governments in the electric energy sector development is to be most investor-friendly Services Provider. Their mission is to create opportunities for all and operate highly efficient Governments by providing competitive incentive schemes, excellent support facilities and services (granting permits and licenses) for the purpose of creating enabling environment for the construction of the aforementioned Power Plant.

Several factors are responsible for the adoption of the Federal and State Governments electric energy development scheme, among which are the diversification of the revenue base of the economy and employment generation and to encourage import of goods and export through local production. The Federal and State Governments will approve and grant all licenses and permits to the exclusion of all other Governmental Agencies, enforce obedience and compliance to rules and regulations. In effect, the Federal and State's laws, which permit the Authority, their Boards, the Developer and the Project Owner to define the policy directions of the Project operation and provide one-stop-shop business transaction without bureaucracy. A new dimension has been added to the propagation of the scheme and this involves private Sector participation and partnership with the Federal Government and other tiers of government, called the Private Public Partnership (PPP).

Thanks for the democracy, Nigeria is taking its rightful place as the preferred investment destination in Africa. Astute investment both; local and foreign are scoring the land of Unity in diversity and taking advantage of the opportunities it offers. When the Project is fully operational, Enugu State would have taken the lead in opening a large window of high living standard changes with the continent.

3. CONLCUSION

The demographic, historical, economic and political analysis and study show that Enugu is a state with huge investment opportunities because it is one of the most peaceful and stable in Nigeria due its strategic geographical location. Besides, Enugu has the following investment potentials:

- one of the fastest growing economies in Nigeria;
- huge potentials for increased Return on Investment (ROI);
- The world bank recently rated Enugu as second most advanced State towards Ease-of-Doing Business;

- Enugu's weather climate is topnotch for agricultural and farming business; other investment opportunities include agricultural, manufacturing, healthcare, tourism, energy, mining, real estate, transportation and more.
- Enugu's technology investment in opportunities has immense benefits;
- The State has many educated, energetic and vibrant labourers, which is a very important investment factor for the Free Trade Zone.

NOTE:
The main objective of this technoeconomic study is to carry out the bankable development of this 10 MWh IGCC power Project, which shall be implemented in the ENPOWER FREE TRADE ZONE (EFTZ) in Enugu, under export credit or export investment credit (Buyer's Credit or Seller's Credit) by the Technical and Financial Consortium of MDA CAPITAL INVEST, A.S. (MDACI).

CHAPTER II: THE PROJECT

1. INTRODUCTION

The project consists of the Bankable Development, including Engineering, Procurement, Construction and Operations Management of an embedded 10.2 MWh IGCC power plant, for the **Enpower Free Trade Zone.** The main objective of this power plant is to secure 24/7 electric power supply to all industrial, commercial and residential properties and facilities located within the zone, easing their operations and businesses. Without electricity, no business can never be effectively, efficiently and profitably operated and managed. So, this power plant is an essential, vital and indispensable project to the free trade zone and to all the businesses within the zone.

The operating costs data used in this report are divided into two categories. Those fuel-operating costs that are expensed for ratemaking purposes are called O&M costs, while those nonfuel-operating costs that are capitalized are called “capital additions.”

This preliminary study has estimated that approximately 2.96% of the total reported O&M costs are labour related, and the remaining 97.04% are for expenditures on maintenance materials and supplies. It has been estimated that for a typical 4,800-megawatt/day maximum plant, which is cca. half (1/2) of the total installed capacity of this 10 MWh IGCC Project, about 15.40% of the staff perform maintenance and support activities. Project operators comprise about 25.55%, and security workers about 11.13% of the total on-site staff. Most of the remaining 19.32% perform various administrative and managerial activities.

It must also be noted that some capital additions cost data are negative. In some cases, negative capital additions costs result when the cost of replacing a plant component is less than its salvage value. However, most negative capital additions costs tend to occur in the first few years of a plant’s operation, and in most cases they are due to regulatory treatment of the original capital costs. *For example, a disallowance of a plant’s original capital costs can result in a decrease in the cost-of-plant account and therefore a negative capital addition for that year. Cost disallowances will be identified for this plant in the study, and in some cases the data will be excluded.*

Nigeria does not have adequate electrical power generation capacity to supply the electrical requirements of the nation. In order to provide the electrical demand, the Federal Government of Nigeria (FGN) has recognized the need to develop coal-fired power plants and revitalize Nigeria's coal mining industry to provide fuel for power generation. In addition, large quantities of trees are harvested each year for domestic heating and cooking causing severe deforestation problems in some parts of Nigeria. FGN is promoting the development of coal briquettes to replace wood for domestic heating and cooking.

Behre Dolbear & Company, Inc. (Behre Dolbear) was engaged by the Federal Ministry of Solid Mineral s Development (Ministry) under a USTDA Grant Agreement dated July 20,

2004 for a study to support Nigeria's proposed Coal Resource Development Program (The Coal Program).

2. GOALS AND OBJECTIVES OF THE STUDY

Under the terms of this Study, Behre Dolbear & Company, Inc. was commissioned to conduct investigations to:

- the potential demand for coal for electrical power generation and domestic use;
- evaluate the available coal resources data and estimate the coal resources internationally accepted resource criteria;
- identify the deposits that have the highest potential for near term development, utilising international test coal industry practices;
- determine the potential of developing an economically viable coal mining and power generating industry to supply electrical energy to the Nigerian electrical grid;
- evaluate the potential for substituting wood with coal briquettes for domestic heating and cooking;
- identify the most effective strategies to attract foreign Companies to revitalize the Nigeria coal and coal-fired power generation industry; end
- the impact of a revitalized coal end electrical power industry on the Nigerian economy.

In conducting the Study, a team of seven Behre Dolbear professionals along with eight professionals from its Nigerian subcontractor Global Minerals Limited has:

- inspected the existing mines and evaluated the known coal deposits in Nigeria;
- met with representatives of the Federal Ministry of Mines and Steel Development (FMMSD), Nigeria Electrical Power Authority – NEPA (actually called the Power Holding Company of Nigeria – PHCN), Nigeria Coal Corporation (NCC) and other agencies, and obtained the available information regarding the coal deposits and the current and projected electrical demand;
- met with and obtained information from participants involved in the development of coal briquetting technology;
- prepared estimates of the latent demand and projections of future demand for electrical power, end projected the required coal production to meet the demand for electrical power and for briquette production;
- evaluated and quantified the coal deposits and identified a short list of the coal deposits that appear to have the highest: potential for the development of economically viable mining operations;

- developed coal resource estimates base on internationally accepted Joint Operating Resource Committee of the Australasian Institute of Mining and Metallurgy Code (JORC Code) for the short list of the most economically viable coal based on the available information;

- the potential of rehabilitating several idle mines, and identified the international best mining methods and technology for exploiting the high potential deposits;

- developed mining plans and projections for optimum production, estimated the capital costs to develop New mines, and the cost of producing coal from mines in the high potential deposits;

- determined the optimum capacity and the estimated capita cost end electrical generating cost of mine mouth coal-fired power plants designed to burn coal from these deposits;

- prepared a strategic plan to attract highly qualified international Companies to participate in the development of coal mining and coal-fired electrical generating operations; end

- the economic impact and environmental risks of developing a modern coal industry in Nigeria.

This scope of works carried out by Behre Dolbear & Company, Inc demonstrates the active involvement of the FGN and the private sector in the development of the Coal-to-Power generation in Nigeria, which started more than 20 years ago.

3. BACKGROUND

3.1 Nigeria Background Information

Nigeria is located in West Africa about 10 degrees north of the equator, and is bordered on the west by the Republic of Benin, on the north by the Republic of Niger, and on the east by the Republic of Cameroon. To the south, the country is bounded by approximately 800 kilometres of the Atlantic Ocean, from Badagry in the west to the Rio del Rey in the east. Nigeria occupies an area of 923,800 square kilometres and the vegetation ranges in gradation from tropical and mangroves on the coast to desert in the far north.

Nigeria was a British colony but became independent in 1960. Six years later, Nigeria first came under military rule. After a civil war between 1966 and 1970, there was a brief return to democratic governance between 1979 and 1983, then a relapse into military rule. Nigeria finally returned to democratic rule in 1999 under a presidential system with three tiers of government at the federal, state, end local levels. The federal level is comprised of an executive arm, a bicameral Legislative arm, and a judiciary arm. There are 36 states and a Federal Capital Territory. Each state has its own executive arm and house of assembly. Each state is further divided into Local Government Areas (LGAs). There are 774 LGAs and each has a chairmen and council.

Nigeria is strategically positioned in West Africa with an Atlantic Ocean coastline of 853 km. It borders Benin to its west and Cameroon in the east while Chad and Niger encloses the northern frontiers.

Nigeria is Africa's most populous nation with a population of 170.1 million[4]. Although the country occupies a large land area of about 924,000 square kilometres, its high population translates to an accordingly high population density of around 184 people per square kilometre.

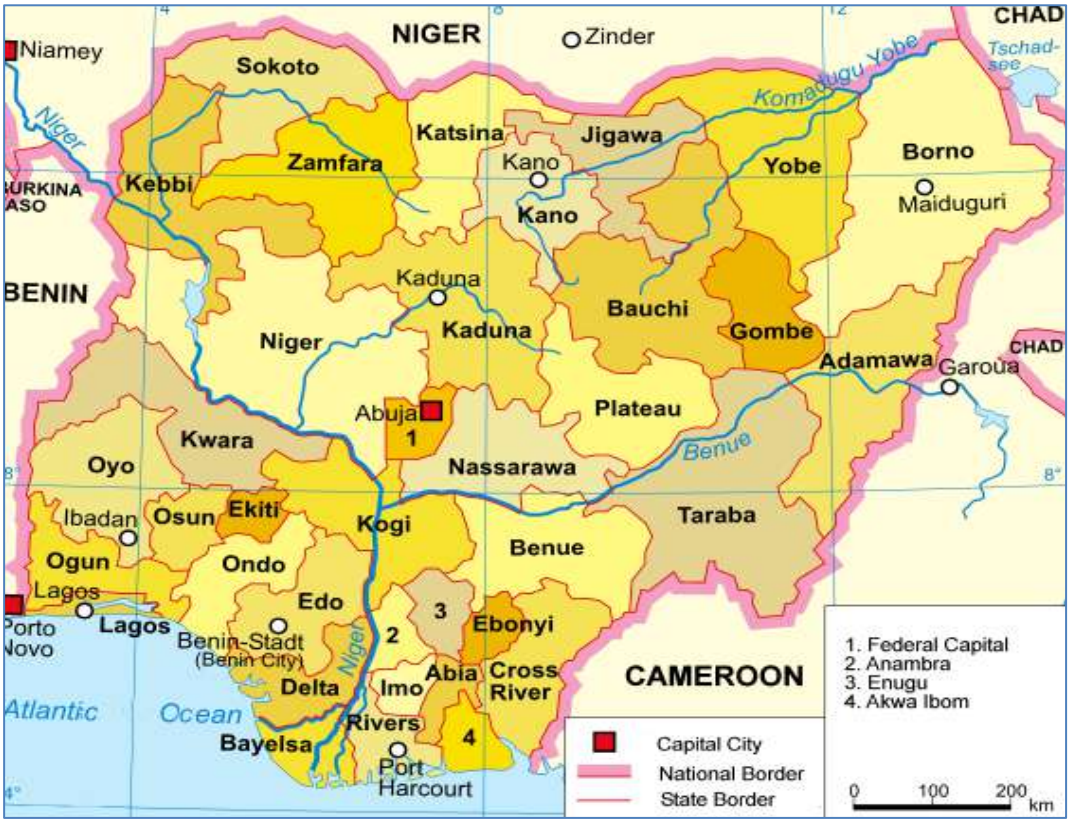

Fig. 2 – Map of Nigeria exhibiting its 36 states and the federal capital territory (*Source: Google*)

The Nigerian economy has experienced a continuing growth in the last several years. In recent years the Gross Domestic Product (GDP) increased by more than 6 % annually. Nigeria's major export is petroleum.

As shown below in Figure 2, the country has 36 states and one Federal Capital Territory (FCT). Abuja (population 1.6 million) is the capital and Lagos (10.4 million) is the largest city and the country's commercial centre. Other important cities are Ibadan (5.5 million), Benin (2.6 million), Kano (2.4 million), Port Harcourt (2.3 million), Aba (1.8 million), Maiduguri (1.2 million) and Ilorin (1.2 million)[5].

According to the Gross Domestic Product (GDP) figures released by International Monetary Fund (IMF), with a nominal GDP of around US$ 244 billion in 2011, Nigeria is now the second−largest economy in Africa after South Africa, having recently surpassed

[4] EIU Country Report, January 2013
[5] EIU Country Report, January 2013 and www.world−gazetteer.com

Egypt. Morgan Stanley, an US−based investment bank, stated in an article in June 2011 that Nigeria's economy could overtake that of South Africa by 2025.[6]

Nigeria has registered real GDP growth rates in excess of 6% since 2008, reaching 7.9% in 2010. The real GDP growth rate in 2011 was 7.5% and the Economist Intelligence Unit (EIU) forecasts a growth rate of 6.2% in 2012.[7]

3.1.1 Nigeria's Electrical Power Industry

The electricity supply in Nigeria is characterized by frequent power failures end load shedding resulting in economic losses through lost production, damaged equipment, and the need for expensive stand-by power. Nigeria has an excessive reliance on its gas-fired and diesel-powered generating facilities while coal reserves remain underutilized.

There are currently 23 grid−connected generating plants in operation in the Nigerian Electricity Supply Industry (NESI), with a total installed capacity of 10,396 MW and available capacity of 6,056 MW[8]. Most generation is thermal based, with an installed capacity of 8,457.6 MW (81% of the total) and an available capacity of 4,996 MW (83% of the total). Hydropower from three major plants accounts for 1,938.4 MW of total installed capacity (and an available capacity of 1,060 MW). Estimates of self−generation plant capacity vary from 4,000 MW to 6,000 MW. The recent Roadmap for Power Sector Reform (the Roadmap) prepared by the Presidential Task Force on Power (PTFP) estimated self−generation of electricity from self−generation sources to be a minimum of 6,000 MW in 2010**.** Manufacturers have estimated that over two−thirds of their power needs have in recent years been supplied by self−generation.

The Nigerian power generation sector comprises the following:

1) PHCN SC power plants which are owned by the Bureau of Public Enterprises (BPE) and Ministry of Finance Incorporated (MOFI). Privatisation of the seven PHCN SC plants is underway (Kainji and Jebba are under one PHCN SC). These have a total installed capacity of 4,323.4 MW, of which 1,944 MW is available to the system.[9]

2) Three other FGN power plants, the privatisation of which has followed a different route than that of the SC generation plants mentioned above, and still operated by PHCN. These are the Egbin, Omotosho I and Olorunsogo I power plants. These facilities have a total installed capacity of 1,990 MW and a total available capacity of 1,422 MW.[10]

3) NIPP power plants, which will ultimately comprise 5,453.2 MW[11] new generating capacity. Five of these plants are currently supplying power to the system. Total

[6] "Nigeria's Economy Could Overtake South Africa by 2025, Morgan Stanley Says" by Maram Mazen, 28 June 2011, www.bloomberg.com/news
[7] EIU Country Report, January 2013
[8] PHCN, NDPHC
[9] PHCN, as of January 30, 2013
[10] PHCN, as of January 30, 2013
[11] Assuming a design capacity of 1,131.4 MW for the Alaoji Power Plant

installed capacity of these plants as of March 2013 was 1,955.6 MW and available capacity was 1,370 MW.[12]

4) Independent power producers (IPPs): These have a total installed capacity of 2,127 MW, of which 1,320 MW is available.[13]

5) In addition to the above, there are a number of self–generators that sell surplus electricity to the grid.

Privatisation of the energy sector has already been initiated through the Electric Power Sector Reform Act of 2005. The Power Holding Company of Nigeria (PHCN) has been unbundled into generation, transmission, and distribution companies that have become privatized. Meanwhile, several IPPs are already operating in Lagos, Abuja, and Port Harcourt.

Nigeria permits 100% repatriation of profits and offers a number of basic facilities that *are* necessary for the conduct of coal mining md power generation including:

- provisions for 100% foreign ownership of mining concerns and power generation plants;
- developed infrastructure including road links, railways, deep ocean terminal, and jetties;
- Export Processing Zones and Free Trade Zones;
- a national electric power grid that is currently being upgraded; local markets for industrial commodities;
- an existing Stock Exchange;
- fixed and mobile communication systems;
- several private and state-owned airlines with daily flights between major cities; and
- existing joint venture md production sharing contracts.

3.1.2 Nigeria's Coal Mining History

Coal was first discovered in 1909 near Udi (central eastern Nigeria). In 1950, the Nigerian Coal Corporation (NCC) was formed with the responsibility for exploration, development, and mining the coal resources. The NCC is 100% owned by the Federal Government and headquartered in the City of Enugu. NCC has operated two underground mines and two surface mines located on the eastern edge of the Anambra Coal Basin north of Enugu. Between 1950 and 1959, coal production increase annually from 583,487 tonnes to a peal of 905,397 tonnes. From this peak, production declined significantly each year including

[12] It should be noted that 582.5 MW of this capacity is stranded generation due to the unavailability of gas and transmission problems. 787.5 MW is actually being dispatched onto the grid (March 2013).
[13] As of January 30, 2013

the Civil War period of 1966 to 1970 when no coal production was reported. Production in the 1980s was less than 100,000 tonnes annually and decrease further in the 1990s. Much of this production was utilized by the railroad and other domestic markets, end NCC a1ro constructed and operated a coal preparation plant near Enugu to upgrade the coal quality for export and has exported some coal, but NCC has not operated any coal mines for several years. The Government of Nigeria has already liquidated NCC and privatized the coal mining industry.

Coal resources have been estimated at 2.5 billion tons, lignite at 250 million tons, and limestone at 600 million tons that are spread over fifteen states.

The government has signed its first production sharing agreement with Nordic Industries, a consortium of Danish, British and local firms to develop its coal industry. The Okab/Odigbo mine district in the northern Kogi State has reserves estimated at 22 million tons and is due to be developed. The Enugu mine has a capacity to produce 150 000t/year.

During 2002 the MSMD gave the go-ahead for a joint venture between South African group LSC Consortium and Polish company Kopex to exploit coal from mines at Mnyeama, Okpara and Owupka.

Actually, private local mining Companies such as OIL DATA INTEGRATED CONSULTING COMPANY LIMITED shall secure the supply of coal fuel to the plant site through railways or roads under Cost, Insurance and Freight (CIF) basis to the power plant site. OIL DATA INTEGRATED CONSULTING COMPANY LIMITED is engaged in the business of oil and gas and mining activities. OIL DATA INTEGRATED CONSULTING COMPANY LIMITED has acquired the Oji Coal Mine Exploration License (No. 13471 EL) from the Federal Ministry of Mines and Steel Development (FMMSD). The Coal mine shall be developed by BANSKE PROJEKTY OSTRAVA, s.r.o. of MDACI Consortium. The mining activities shall be carried out with modern mining equipment and assembled crop of mine management team (comprising foreign and local expert) with proven competencies in specific areas. Our services include:

- Delivering of coal to industrial users such as cement industries;
- Delivering of coal to proposed IPPs that will use coal as fuel;
- Consulting on coal mining.

4. POWER PLANT DESCRIPTION

The embedded 10 MWh IGSC power plant shall be built on **1.6ha of Land** with the provision of possible expansion to higher capacity in the future. The technoeconomic development of the project shall provide two (2) design proposals of the power plant: 1) Integrated Gasification Simple Cycle (IGCC) of cca. 10 MWh power plant; and 2) Integrated Gasification Combined Cycle (IGCC) of cca. 13.5 MWh power plant. As stated above, **the design philosophy of the power plant consists of two (2) variants.** The **first variant** (or **stage 1**) shall consist of three (3) High performance MWM TCG 2032 V12 Genset of total capacity or power output of 3,333KWh (or 3.333 MWh), while the

second variant (or **variant B**) the IGCC power plant shall be provided with Three (3) High performance **Genset (MWM TCG 2032 V12)** Genset and 1 x standard **single-stage Steam Turbine (D-R SST 350 / 500 / 700)** of total power output of 3,500 kWh (3.50MWh). The Total installed capacity or power output of Variant A and Variant B are respectively **9,999 KWh (≈ 10 MWh)** and **13,500 KWh (13.50 MWh)**. Both types of power plant are among the most environmentally friendly in the world, the quantity of coal and gas used in Variant A is the same as the quantity the quantity of coal used in Variant B. Due to the Steam Turbine used in Variant B, the EPC contract of Variant B is a higher, **and are both technoeconomically and environmentally friendly**. The IGCC power plant is a very simple process, the produced syngas from the Gasifier is first cleaned and directly burned as fuel in the combustion Genset, which then drives the Three-phase MJH 800MC6 Synchronous Generators.

The Integrated Gasification Combined Cycle (IGCC) is a process whereby a hydrocarbon feedstock (coal) is converted into gaseous components by applying heat under pressure in the presence of steam. Rather than burning, most of the carbon-containing feedstock is broken apart by chemical reactions that produce "syngas." Syngas is primarily hydrogen and carbon monoxide, but the exact composition can vary. In Integrated Gasification Combined-Cycle (IGCC) systems, the syngas is cleaned and burned as fuel in a combustion turbine which then drives an electric generator. Exhaust heat from the combustion turbine is recovered and used to create steam for a steam turbine-generator. The use of these two types of turbines in combination is one reason why gasification-based power systems can achieve high power generation efficiencies. Currently, commercially available gasification-based systems can operate at around 40% efficiencies. Coal gasification (clean energy of the future) is also water intensive. According to the Gasification and Syngas Technologies Council, a trade association, there are globally 272 operating gasification plants with 686 gasifiers and 74 plants with 238 gasifiers under construction. Most of them use coal as feedstock.

Furthermore, the **discharge of solid by-products and waste waters** is reduced roughly by 50% versus other coal-fed plants, and the by-products generated (mainly **slag** and **sulphur**) are environmentally benign and can be sold.

This embedded power generation, also called or autoproducer, is an electricity generation facility used and managed by an industrial or commercial energy user (e.g. XENERGI FZE) for their own energy consumption. Embedded Generation is simply a generation of electricity for local distribution and consumption. It can also be connected to the electric grid to exchange excess generation. The development of embedded generation has an important part to play in meeting the Government's long term environmental targets. Some of the advantages of Embedded Power Generation include:

1) the reduction in transmission losses and in construction cost;
2) environmental concerns;
3) prevention of excessive supply of electricity to the grid;
4) stability and reliability; and
5) supply and demand matching.

4.1 Plant Availability

A total yearly working time of 85 % has been assumed for all of the options, which is equal to **7,446 hours/year**. For the purpose of this study report, we will use a Total Number of Operating Hours (TNOH) of **8760 hours/year** because the plant is designed to supply uninterruptedly (*i.e.* 24/7) power to the **EFTZ**.

4.2 Infrastructures and Facilities

The IGCC power plant shall be provided with the following operations facilities:

1) Power Generation Hall – PGH;
2) Own Integrated Wastewater Treatment Plant (WTP);
3) Coal Storage and Treatment Hall – CSTH;
4) Residues Collection, Treatment, Disposal and Package Hall (RCTDPH)
5) Administration Building – AB;
6) Internal Parking Spaces (IPS) for staff only and coal delivery trucks; and
7) External Parking Area (EPA) for visitors.

The water shall be piped from Orji River situated at a distance of cca. 20 km from the power plant. For economic purposes, the power plant may use the underground water as a backup water supply. This underground does not require any further treatment. It has been mapped as one of the cleanest underground waters in the world.

The plant shall be built for a period of **12-24 months** as provided in the **Project Implementation Milestone**, Section 4.2.

4.3 Fuel Data Analysis – Primary and Secondary Fuels

The quality of this coal was provided by the Managing Director/CEO of XENERGI LIMITED. It was based on the laboratory report No. 2020/0002 issued by NIGERIAN GEOLOGICAL SURVEY AGENCY (National Geosciences research Laboratory (NGRL) in Kaduna). But, as provided in Table 1 below, there are some missing important data such High Heating Values (HHV), methane, and Carbon Monoxide (CO).

Table 1: Coal Quality Specifications

Parameter	Value
Total moisture, Wr (%)	6.15
Ash, Ar (%)	11.05
Total sulphur, Sr (%)	0.58
Calorific value, LHVr (kJ/kg)	20,675.42
Moisture, Wa (%)	**N/A**
Ash, Aa (%)	N/A
Volatiles, Va (%)	N/A
Heat of combustion, HHVa (kJ/kg)	N/A
Calorific value, LHVa (kJ/kg)	N/A
Sulphur, Sa (%)	0.58
Carbon, Ca (%)	65.87
Hydrogen, Ha (%)	4.97
Nitrogen, Na (%)	1.26
Oxygen, Oa (%)	10.13

The evaluation of the coal quantity was based on the most accurate method, using the fuel consumption data from the manufacturers and a fuel of known properties procedures provided by XENERGI FZE/XENERGI LIMITED. The verification of data was based on the **Stoichiometric Modelling** provided in table 1-2 below.

Although over one hundred chemical compounds take part in the gasification process, in the presented model only eight substances, which are considered **C**, **CO**, **CO**, **HO**, **H**, **CH**, **O** and **N**.

Nitrogen is treated as inert, so seven compounds, formed from three elements, participate in conversions. Therefore, the model was determined by four independent reactions. Usually, the following reactions are used in equilibrium simulations.

Table 2: Stoichiometric Modelling

Eq.	Name	Chemical Reaction	Energy
1	the Boudouard reaction	C + CO2 → 2CO	+172 MJ/kmol
2	the water gas reaction:	C + H2O → CO + H2	+131MJ/kmol
3	the methanation reaction:	C + 2H → CH4	–75 MJ/kmol
4	the water gas shift reaction:	CO + H2O → CO2 + H2	–41MJ/kmol

NOTE 1:
When considering the quality specifications of your coal, you can see that we have only four (4) components. Besides, we do not have any data on the high heating value (HHV_{coal}), which is a very important data for the combustion of the coal and Syngas. The preliminary analysis of the coal specifications we received from you shows that your coal has a good Heating Value for coal-fired power generation and very poor chemical composition for the production of syngas.

4.4 Main requirement for the combustion of gas

The combustion gas refers to gas mixtures, which are suitable for turbine/genset operation and differ in their composition. The most important main components are:

- **Methane (CH_4)**
  - as an essential heating value carrier of the usual combustion gases,

- **chained hydrocarbons (C_nH_m with n greater than 1)**
  - which have a strong tendency towards knocking combustion,

- **inert gases (N_2 and CO_2)**
  - which do not actively participate in the combustion. Inert gases increase the methane number in a combustion gas. This increases the methane number in CO_2 with the triple effect of N_2,

- **Hydrogen (H2)**
  - which considerably reduces the methane number of the combustion gas.

NOTE 2:
As you can see here in this section, your coal dot not contain the most important combustion elements like methane and any or hydrocarbons (CH_4) and (C_nH_m with n greater than 1).

4.5 Accompanying substances

The gas accompanying substances are also very important in the assessment of suitability as a combustion gas. They make no significant contribution to the combustion energetically. However, these gas accompanying substances must be taken into account with regard to the reliable operation of the overall system.

In addition to the gas accompanying substances which do not change the combustion process, there are also substances which lead to a change in the ignition properties (such as oil fumes).

Other gas accompanying substances are significant because of the combustion products such as ashes or deposits. These are elements and compounds which contain silicon, halogens, metals, etc.

Although the accompanying substances only occur in traces, the combustion products can cause wear.

Depending on the amount and damage effect, these gas accompanying substances must be eliminated from the combustion gas before entering the gas control line.

Examples: The syngas should not be mixed with any of the following elements or with gas containing these elements.

- **Hydrogen sulphide H_2S** from *e.g.* biogas combusts to SO_2 and H_2O. These two intermediate products react to sulphurous acid H_2SO_3. A further reaction to sulfuric acid H_2SO_4 is possible in the oxidation catalyst. The acids formed in the combustion cause the lube oil to become acidified, which leads to the lube oil replacement intervals becoming shorter. Furthermore, sulphurous and sulfuric acid can condense in the exhaust heat exchanger and lead to deposits and corrosion occurring there.

- **Silicon connection hexamethylcyclotrisiloxane D_3 $(CH_3)_6Si_3O_3$** *e.g.* from landfill and sewage gas combusts to silicon dioxide SiO_2 (quartz sand), CO_2 and steam. Silicon dioxide forms deposits on all components surrounding the combustion chamber, which leads to abrasive wear. Furthermore, the deposits cover the exhaust catalyst and deactivate it.

- **Chloroform $CHCl_3$** *e.g.* from landfill gas reacts to hydrochloric acid, carbon dioxide and steam. This hydrochloric acid pressurizes the lube oil and corrodes components.

4.6 Heating Values of Syngas required

Based on the specifications of this Syngas Genset, the heating value of the syngas are as given in the table below.

Table 3: Required Syngas Heating Values

	Min. HV	Typical HV	Max. HV
MJ/m³	**15.7613**	**17.7171**	**19.6729**
MW/m³	0.2627	0.2953	0.3279

4.7 The minimum Quantity of Syngas required for the generation of 10MWh

- **Q_{SYNGAS}** for **HV_{SYNGAS} = 15.7613 MJ/m³**
  We have the following inputs:

  - Thermal Efficiency (TE): 96%
  - If the thermal efficiency is 75%, then the flow rate shall be **816.60m³**.

4.8 The minimum coal heating value required for the generation of 10MWh

The total quantity of Syngas required per year for the generation of a total power out of **10.2 MWh** shall be **21,460,248 m³**. In order to meet the combustion requirements of the syngas, the following gases and respective quantities shall be injected to the syngas produced from your coal:

a) Methane (HHV 39.76MJ/m³) – 22% of 21,460,248 m³ (*i.e.* 4,721,254.56 m³); and
b) Hydrocarbon (HHV 12.76MJ/m³) – 1% of 21,460,248 m³ (*i.e.* 214,602.48 m³).

So, the total quantity of additional combustion gases is: **ADDITIVE = 4,935,857.04 m³**. Another suitable gas such as Natural Gas, LNG, LPG, Biogas, Landfill Gas, Sewage Gas, Coke Oven Gas, Mine Gas, Propane or Associated Gas of the same quantity and quality i.e. (a minimum Heating value of **39.76 MJ/m³**).

4.9 Quantity of coal required for the generation of 10.2 MWh

The quantity of coal with a heating value of 20, 676.41 KJ/Kg for the 3 x 3.333 MWh (≈10MWh = 10,000kWh) per year is: **Qcoal = 87,591.24 ± 5%** MT / year (**91,970.80 MT/yr**.). Therefore, the quantity of Coal Fuel Consumption Rate is: **10.90 MT/hr**.

From the obtained coal, we have**: ΔH_{min} (2m³ syngas) =** 1.27MJ/m³.
For the Genset: **ΔH_{min} (2m³ syngas) =** 31.52 MJ/m³.

a) The quantity of Syngas generated by 1kg of coal (20,675.42 kJ/kg) is: 0.61 m³.

b) The coal assumption used is 1 kg of coal of high heating value generate 2 m² of syngas of a minimum heating of 15MJ/m³. The calculated results from this assumption give 1.363 Nm³ (1.40 Nm³) of syngas.

c) The calculation of the heating value of volume of syngas calculated uniquely from the received coal data is 0.61 m³ (0.60 m³). The sum of these values gives: 0.61 m³ + 1,363 m³ = 1.973 (≈ 2m³), which corresponds to the exact assumed value.

5 MAIN TECHNOLOGIES AND EQUIPMENT OF THE POWER PLANT

5.1 THE GENSET TGC 2032 V12

This is the preliminary selected Syngas Genset due to its reliability, efficiency and economic operation. **TGC 2032 V12** operates with all types of gas, which are available in Nigeria, including syngas. This IGCC power plant project is the first project of its kind the whole Africa and in Nigeria, besides the huge coal deposit in Nigeria and particularly in Enugu (also known as the call state of Nigeria), where this project is actually being implemented.

More profit. The optimized maintenance concept with cylinder units simplifies accessibility and, along with the reduction of the number of different parts, minimizes the time required for maintenance. This saves up to 20% in service costs. At the same time you profit from up to 30 % less lubricating oil consumption compared to other engines.

Longer runtimes. Thanks to the extended service intervals, the TCG 2032 runs up to 200 hours longer per annum than comparable products. The major overhaul is scheduled after 80,000 operating hours.

Greater reliability. The particle-free combustion with chamber plugs extends the service intervals for the exhaust gas heat exchanger and reduces service costs compared to other combustion methods.

Major components such as pistons, conrods, spark plugs and cylinder heads have been improved to withstand the greater power output and deliver increased electrical efficiency.

Optimum efficiency. The interaction of all components has been improved even further. All components relevant for efficiency and power output are monitored by the TEM (Total Electronic Management). The new, upgraded wastegate in particular ensures a more efficient operation with changing conditions. This is also the case when the gas composition is fluctuating – thanks to fast response times due to the temperature monitoring for each cylinder. TEM not only controls the engine, but the entire system, including heat extraction.

Full turbo power. The high-pressure turbocharger A140 with an improved wastegate allows operation with a broader air intake temperature range and up to higher altitudes.

5.1.1 Technical Data of the Genset

Table 4: Technical data and fuel chemical composition requirements

Parameter	Value	
Electrical power	kW	3,333.0
Mean effective pressure	bar	20.0
Thermal output	kW	3,238.0
Electrical efficiency	%	43.9
Thermal efficiency	%	42.6
Total efficiency	%	86.5
Length	mm	7,860
Width	mm	2,660
Height	mm	3,390
Dry weight genset	kg	43,100

	Minimum	Minimum	Minimum
Carbon dioxide (CO_2) in %	1	2	4
Ethane (C_2H_6) in %	0.5	1,5	3
Methane (CH_4) in %	22	25	28
Carbon monoxide (CO) in %	3	5	7
Hydrogen (H_2) in %	**52**	**56**	**60**
Nitrogen (N_2) in %	**8**	**10**	**12**
Oxygen (O_2) in %	**0**	**0.5**	**2**

5.2 STEAM TURBINE (D-R SST 350 / 500 / 700)

Standard Dresser-Rand SST Turbines are single-stage, impulse-type turbines with a two-row, velocity-compounded rotor and one row of stationary reversing blades between the rotating blades. The rotor is contained within a horizontally split (axially split) casing, with steam inlet and exhaust connections located in the lower half of the casing assembly.

The rotor is supported between two sleeve bearings and positioned axially by a ball thrust bearing or tilt pad thrust bearing, or it is supported between two ball bearings and positioned axially by a ball thrust bearing. Other variations of the turbine include extended inlet pressure and temperature constructions and/or a high back pressure construction.

Steam enters the turbine casing after first passing through the built-in steam strainer, the throttle valve and the overspeed trip valve. The turbine inlet casing incorporates the nozzle ring, which contains several individual steam nozzles. Some of these nozzles are controlled by hand-valves for partial load or overload conditions. Steam flowing through the nozzles expands and is directed at high velocity against the rotating blades of the first row on the turbine rotor. After passing through the first row, stationary reversing blades redirect the steam against a second row of rotating blades. The steam is then discharged into the exhaust casing and from there into the user's exhaust piping at the exhaust system pressure. Optionally, the turbine may be supplied with a single row rotor, in which the case stationary reversing blades are not provided. This Steam Turbine (ST) is a standard single-stage steam turbine, consisting of:

- Rugged, versatile design
- Woodward TG Oil Relay NEMA Class A constant speed or electronic governor
- Horizontally split casing with centreline support
- Overspeed mechanical trip valve, separated from governor valve

- Carbon ring or labyrinth sealing glands
- Built-in, removable steam strainer
- API style blanket lagging / insulation (API applications)
- Oil ring with forced pressure lubrication or circulating oil cooling options
- Rolling element or tilting pad thrust bearings
- Broad range of controls and accessories available
- WORTHINGTON heritage (D-R SST 350 / 500)

5.2.1 Technical Data of the Steam Turbine

Table 5: Technical data of the Turbine

Parameter	Value	
Electrical power output	kW/HP	3,500 / 4,690
Turbine Speed	rpm	≤ 12,000
Inlet steam pressure	bar(a) / psi	63 / 914
Inlet steam temperature	°C / °F	≤ 482 / 900
Back pressure	bar(a) / psi	202 / 315
Bearings	Sleeve	-
Type blades	Impulse	-
API	-	611 & 612

5.3 GENERATOR (Marelli)

Each Genset and the Steam Turbine (ST) shall be connected to a Three-Phase Synchronous Generator MJH 800MC 6. The technical data of the Generator for a frequency of 50 Hz and a speed of 1,000 rpm are provided in table 1-5 below. (Standards: VDE 0530; IEC 60034-1; BS 4999-5000). Three (3) generators are required, having each a total power output of 3.333 MWh.

5.3.1 Technical Data of the Generator

Table 6: Technical data of the Generator

Parameter	Value	
Frequency	Hz	50
Protection degree	-	IP 23
Power factor	-	0.8
Overspeed	rpm	1,300
Number of terminals	-	6
Cooling temperature	°C	40
Cooling air volume	-	IC 01
Altitude at side	m	1,000
Inertia	Kgm^2	769
Total losses	kW	124.5
Radiated heat	kW	6
Weight	kg	18,400
VOLTAGE (± 10%)	V	10,500
CURRENT	A	294
RATED POWER (@ 0,8 p.f.)	kVA	5,338
EFFICIENCY	%	100-110
Length	mm	3,590
Width	mm	2.060
Height	mm	1,760

NOTE:
*As indicated, installed costs for the turbine/generator range from approximately **US$670/kW to US$1,140/kW**, with costs on a per kW basis declining as capacity increases.*

5.4 ACCESSORY ELECTRIC PLANT

The accessory electric plant consists of switchgear and control equipment, generator equipment, station service equipment, conduit and cable trays, and wire and cable. It also includes the main power transformer, required foundations, and standby equipment.

5.4.1 Switchgear

The Embedded Power Generation Project shall be provided with its integrated Distribution Network, consisting of the construction of (i) 15 km of low-voltage 33 kV lines (main evacuation lines from the power station); (ii) 15 km of low-voltage 11 kV lines; (ii) 15 km of low-voltage 0.4 kV lines; (iii) the purchase and installation of 20 transformer stations; (iv) 10,000 smart prepaid meters for connecting 10,000 new customers, and a 1,000 galvanized Steel Power Poles.

5.4.2 Instrumentation and Control

An integrated plant-wide control and monitoring DCS is provided. The DCS is a redundant microprocessor-based, functionally distributed system. The control room houses an array of multiple video monitor and keyboard units. The monitor/keyboard units are the primary interface between the generating process and operations personnel. The DCS incorporates plant monitoring and control functions for all the major plant equipment. The DCS is designed to provide 99.5% availability. The plant equipment and the DCS are designed for automatic response to load changes from minimum load to 100%. Start-up and shutdown routines are implemented as supervised manual, with operator selection of modular automation routines available.

5.5 FREE TRADE ZONE CONSTRUCTION SITE LAYOUT

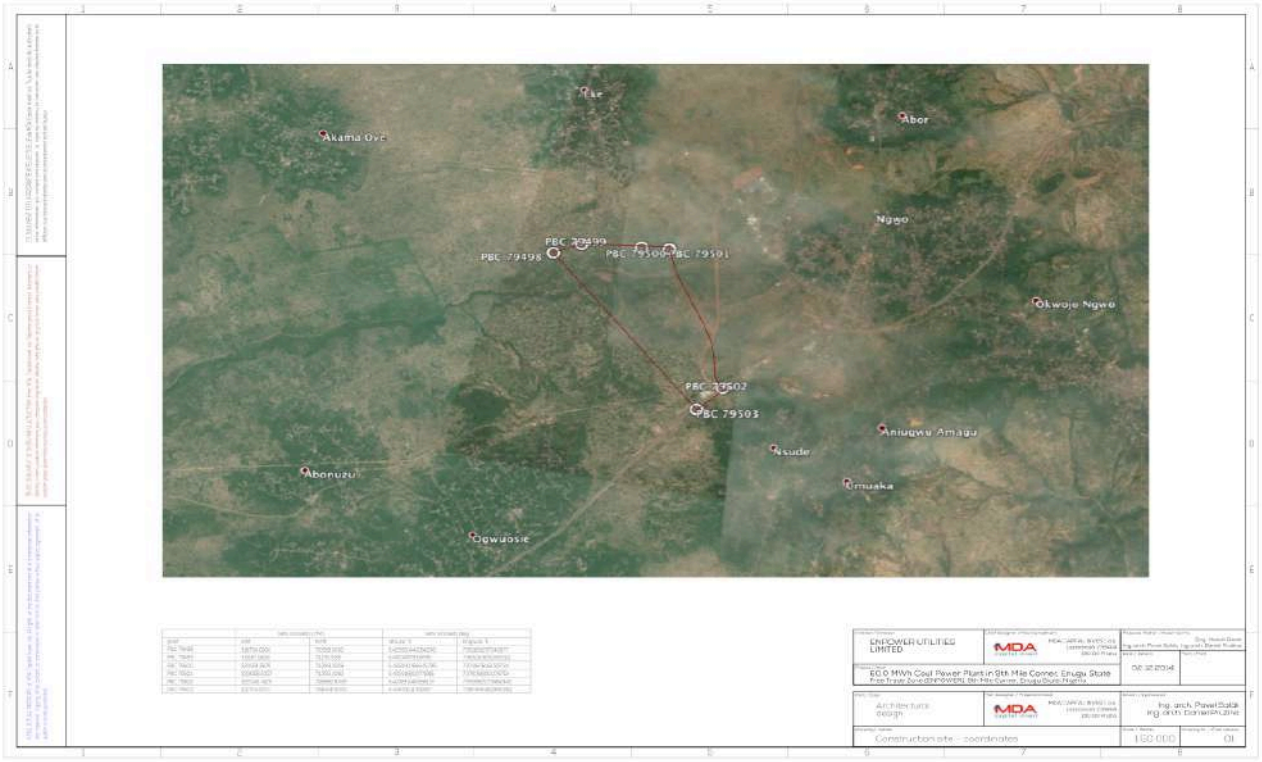

Fig.3 – Free Trade Zone Layout from Google coordinates

Fig. 4 – Free Trade Zone Layout showing the Power Plant Construction Site Layout

5.5.1 Power Plant Design Preview

Fig. 5 – 3D Top-View of the Power Plant

Fig. 6 – 3D Top-View of the Power Plant – Storeroom

Based on the proposed location (Fig. 1.3) of the Power Plant, the Project Company, XENERGI LTD shall provide the following data:

1) **Topographic Map**, indicating the sea levels.

2) **Free Trade Location Map**, showing the most important neighbouring sites like Heineken brewery, highways, access roads, rivers, evacuation canals, etc.; and

3) Soil Test of the selected **1.6 ha** of land area.

NOTE:
This location is very strategic, due to accessibility to highways for easy supply of raw materials, and delivery of technologies and equipment. Besides, it eases the connection of the plant to external important infrastructure or facilities as for instance, piping raw water from Oji River located at 20 km from the site. This is more economically feasible than extracting the underground water, which is used for the brewery.

5.5.2 Design Philosophy

Generally electric power plants fall into several categories and classes depending on the type of prime mover. The **10 MWh IG** power plant design philosophy shall be carried to meet the following customer benefits:

1) Reliability;
2) Simple maintainability; and
3) Future expansion.

Reliability

Plant reliability standards will be equivalent to a **1-day generation forced outage in 10 years** with equipment quality and redundancy selected during plant design to conform to this standard.

Simple Maintainability

Power plant arrangement will permit reasonable access for operation and maintenance of equipment. Careful attention will be given to the arrangement of equipment, valves, mechanical specialties, and electrical devices so that rotors, tube bundles, inner valves, top works, strainers, contractors, relays, and like items can be maintained or replaced. Adequate platforms, stairs, handrails, and kickplates will be provided so that operators and maintenance personnel can function conveniently and safely.

The powerhouse shall be provided with enough access areas to engines, turbines and generators for easy maintenance services. At least a 5m distance between Steam Turbines (STs) foundation boundaries and walls shall be required.

Future expansion

The specific site selected for the power plant and the physical arrangement of the plant equipment, building, and support facilities such as fuel and oil wastes handling systems, circulating water system, scrap storage room, spare parts store, trackage, and access roads, etc. will be arranged insofar as practicable to allow for future expansion.

5.5.3 General Design Criteria and Requirements

The design will provide for a power plant, which has the capacity to provide the quantity and type of natural gas power plant (in the case of simple cycle power plant), steam and compressed air (in the case combined cycle power plant) required. Many of the requirements discussed here are not applicable to each of the plant categories of Table 1-4. A general overview is provided in Table 1-5.

Electric power loads

The following information, as applicable, is required for design:

1) Forecast of annual diversified peak load to be served by the project;

2) Typical seasonal and daily load curves and load duration curves of the load to be served;

3) If the plant is to operate interconnected with the local utility company, the designer will need information such as capacity, rates, metering, and interface switchgear requirements;

4) If the plant is to operate in parallel with existing generation on the base, the designer will also need:
   a) An inventory of major existing generation equipment giving principal characteristics such as capacities, voltages, steam characteristics, back pressures, and like parameters;
   b) Incremental heat rates of existing boiler-turbine units, diesel generators, and combustion turbine generator units; and
   c) Historical operating data for each existing generating unit giving energy generated, fuel consumption, steam exported, and other related information.

5) Existing or recommended distribution voltage, generator voltage, and interconnecting substation voltages;

6) If any of the above data as required for performing the detailed design is unavailable, the designer will develop this data.

Export of steam

1) If the plant will export steam, information similar to that required for electric power, as outlined in subparagraph c) above, will be needed by the designer.

2) Coordination of steam and electric power loads. To the greatest extent possible, peak, seasonal, and daily loads for steam will be coordinated with the electric power loads according to time of use.

NOTE:
*The power plant may export **steam**, **chilled** and **hot water** to the existing Heineken Brewery located at a cca. 200 m from plant, or to the proposed purified bottled water plant, houses, industrial and commercial facilities to be built in the Free Trade Zone.*

Table 7: Design Criteria Requirements

Class (Plant Category)	Electric Power Load	Export Steam Load	Fuel Source and Cost	Water Supply	Stack Emission	Waste Disposal
A (Primary)	A	A	A	A	A	A
B (Standby)	A	N/A	A	N/A	N/A	A
C (Emergency)	Critical Load Only	N/A	A	N/A	N/A	N/A

NOTES:

- *A: Available*
- *N/A: Not Available*
- *This type of information is particularly important if the project involves cogeneration with the simultaneous production of electric power and steam.*

Table 8: General Description of Type of Plants

TYPE OF POWER PLANT				
S/N	**Category**	**Capacity**	**No Export Steam**	**With Export Steam**
1	Primary	Adequate to meet all peacetime requirement.	Purchased electric power to match electric load Continuous duty diesel plant, Class "A" diesel. Straight condensing boilers and turbines matched in capacity as units; enough units so plan without largest unit can carry emergency load	Not stated Purchased electric power and steam to match electric load plus supplementary boiler plant to match export steam load. Automatic back pressure steam plant plus automatic packaged fire tube boiler to supplement requirements of export steam load. Automatic extraction steam plant boilers and turbines matched in capacity se units and enough units installed so that plant without largest unit can carry emergency load.
2	Standby	Adequate with prime source to match mobilization needs; or alone to supply emergency electric load and export steam load in case of primary source out age. Equal to primary source . . .	Purchased electric power. Standby diesel plant, Class "B" diesel. Retired straight condensing plant.	Purchased electric power and steam to match electric power load plus supplementary boiler plant. Standby diesel plant with supplementary boiler plant. Retired automatic extraction steam plant.
3	Emergency	To supply that part of emergency load that cannot be interrupted for more than 4 hours.	Fixed emergency diesel plant, Class "C" diesel. Mobile utilities support equipment.	None None

Water Supply

Fresh water from **River Du** or **Oji River** is required for **thermal cycle makeup** and **for cooling tower or cooling pond makeup** where once through water for heat rejection is unavailable or not usable because of regulatory constraints. Quantity of makeup will vary with the type of thermal cycle, amount of condensate return for any export steam, and the maximum heat rejection from the cycle. This heat rejection load usually will comprise the largest part of the makeup and will have the least stringent requirements for quality.

Stack Emission

A steam electric power plant will be designed for the type of stack gas clean-up equipment, which meets federal, state, and municipal emission requirements. For a solid fuel fired boiler, this will involve an electrostatic precipitator or bag house for particulate, and a scrubber for sulphur compounds unless fluidized bed combustion or compliance

coal is employed. If design is based on compliance coal, the design will include space and other required provision for the installation of scrubber equipment. Boiler design will be specified as required for NO_x control.

5.5.4 The Major Gasification By-products

Slag and Ash. As discussed in the Background, solid waste from conventional pulverized coal-fired power plants is a significant environmental issue due to the large quantities produced, chiefly of coal fly ash, and the potential for leaching of toxic substances (e.g. heavy metals such as lead and arsenic) into the soil and groundwater at disposal sites, and accidental releases from coal ash ponds.

As opposed to conventional coal combustion, many types of coal gasification produce very little fly ash. This is a benefit of gasifiers operated at temperatures higher than the fusion point of ash (slagging gasifiers or agglomerating gasifiers, which include the most prominent coal gasification processes incorporated into IGCC such as GE Energy, E-Gas and BGL, etc.). At such high temperatures, most of the mineral matter of the coal is transformed and melted into slag, an inert glass-like material. Under these conditions, non-volatile metals and mineral compounds are bound together in molten form until the slag is cooled in a water bath at the bottom of the gasifier, or by natural heat loss at the bottom of an entrained bed gasifier. Volatile metals such as mercury are typically not recovered in the slag, but may be removed from the raw syngas during cleanup. Slag production is a function of ash content, so coal produces much more slag than petroleum coke. Regardless of the feed, as long as the operating temperature is above the fusion temperature of the ash, slag will be produced. Its physical structure is sensitive to changes in operating temperature and pressure, and physical examination of the slag's appearance can often be a good indicator of carbon conversion in the gasifier.

More precisely, slag is comprised of black, glassy, silica-based materials (also known as "frit", a high density, vitreous, and abrasive material low in carbon and formed in various shapes from jagged and irregular pieces to rod and needle-like forms) and residual carbon char, the proportions of which vary depending on operating conditions, gasifier, feed, etc. The two parts can be separated (they are not chemically bonded) and concentrated into carbon rich char and vitreous frit. Char has its own current and potential uses; see the following discussion. Vitreous slag is much preferable to ash, because of its habit of encapsulating toxic species (such as heavy metals) into a stable, non-leachable material. Leachability data obtained from different gasifiers unequivocally shows that gasifier slag is highly non-leachable, and can be classified as non-hazardous. Because of its particular properties and non-hazardous, non-toxic nature, **slag is relatively easily marketed as a by-product for multiple advantageous uses, which may negate the need for its long-term disposal**. Obviously, both the profit from using slag as a by-product and avoidance of disposal costs combine to improve the economics of the disposition of slag, which is the major solid by-product from gasification processes.

In summary, the high temperatures and pressures of gasification processes have the potential to turn mineral matter within the feedstock into slag instead of the ash that is produced in combustion. Slag captures toxics/heavy metals and does not allow them to leach out of the material, unlike combustion ash from which toxic species can possibly leach and find their way into groundwater and surrounding soils.

Char. Char is the finer component of the gasifier solid residuals, composed of unreacted carbon with various amounts of siliceous ash. It can be recycled back into the gasifier to increase carbon usage and has been used as a supplemental fuel source for pulverized coal combustion. The irregularly shaped particles have a well-defined pore structure and have excellent potential as an adsorbent and precursor to activated carbon. In a project between the Department of Energy (DOE) and CAER, potential uses of char were investigated, specifically as **adsorbers for emissions control**. Carbon char has the potential to **control mercury (Hg) and nitrogen oxides (NOx) emissions**. To test for mercury adsorption (an initial study only) a mercury vapour generator and a fixed bed reactor were used. A gas sampling system and vapour analyser were used to assess the char's performance. Untreated gasifier char was found to be as effective at adsorbing mercury as a **commercially available activated carbon designed for Hg adsorption**. Interestingly, all attempts to increase the porosity of the gasifier char lessened its adsorption potential, which seems to be related to the **char mineral content (mainly SO_{4-2} and Cl-)**. Not having to treat the char is significant, as treatment would be an additional cost.

Additionally, gasification **char** adsorbed significantly more NOx than all other test materials except for a specially designed activated carbon NOx adsorber. For this test a thermal analyser and mass spectrometer were used. The char performed 30% as well as the specially designed activated carbon adsorber. After increasing the surface area of the gasifier char, it increased NOx capacity, while char that was laden with Hg adsorbed more NOx than Hg-free char. This presents the possibility of using gasifier char to adsorb Hg while also adsorbing some NOx prior to an activated carbon NOx adsorber. Naturally, the gasifier char, a "waste," is significantly less expensive than a specialty adsorber and being able to put it to good use makes plant operations more economical.

Sulphur. Sulphur products are collected, cooled and condensed, generating low pressure steam. Condensed sulphur product is stored in an underground molten sulphur pit, where it is later pumped to truck loading for shipment. Claus tail gas from the last stage sulphur condenser is sent to a tail gas treatment unit to remove unconverted H_2S, SO_2, and carbonyl sulphide (COS) before disposal.

The option to recover sulphur in the form of sulfuric acid (H_2SO_4) is practiced **at Tampa Electric's IGCC demonstration plant**, given the local demand for sulfuric acid for fertilizer manufacture in this area of Florida. Figure 7 shows a simplified flow of the Tampa Electric IGCC sulfuric acid plant. The sulfuric acid plant receives the hydrogen sulphide (H_2S) from the **acid gas recovery** unit and H_2S and ammonia from the water stripper. The gas streams are then burned in a decomposition furnace, where the H_2S produces primarily **sulphur dioxide (SO_2)** with trace amounts of **sulphur trioxide (SO_3)**, sulfuric acid and elemental sulphur and the ammonia is converted to **nitrogen (N_2)** and water. The decomposition furnace exit gas is cooled from about 1,950°F to 650°F in a waste heat boiler to produce medium pressure steam for in plant use. The gas is then further cooled and dried. This step produces a 'weak acid' waste stream which needs to be neutralized before discharging into the cooling pond. The SO_2 and oxygen (from either air or an air separation plant) then react over a vanadium-based catalyst bed in a converter according to the following reaction:

$$SO_2 + ½\ O_2 \rightarrow SO_3$$

The produced SO_3 is then reacted with water as follows:

$$SO_3 + H_2O \rightarrow H_2SO_4$$

The catalytic oxidation of SO_2 to SO_3 is highly exothermic, and the equilibrium becomes increasingly unfavourable for SO_3 formation as temperature increases to about 800°F. For this reason, special catalytic converters (reactors) are designed as multistage reactor bed units with air cooling between each bed for temperature control.

Gas from the final reactor beds enters the absorbing towers, where the produced SO_3 reacts with the excess water in a circulating, strong (98%) sulfuric acid stream, creating additional H_2SO_4. This incrementally raises the concentration of the sulfuric acid so that water is introduced as needed to maintain the H_2SO_4 at 98.5% as the final product. The Tampa Electric sulfuric acid plant is very efficient, converting over 99.5% of the incoming H_2S to H_2SO_4.

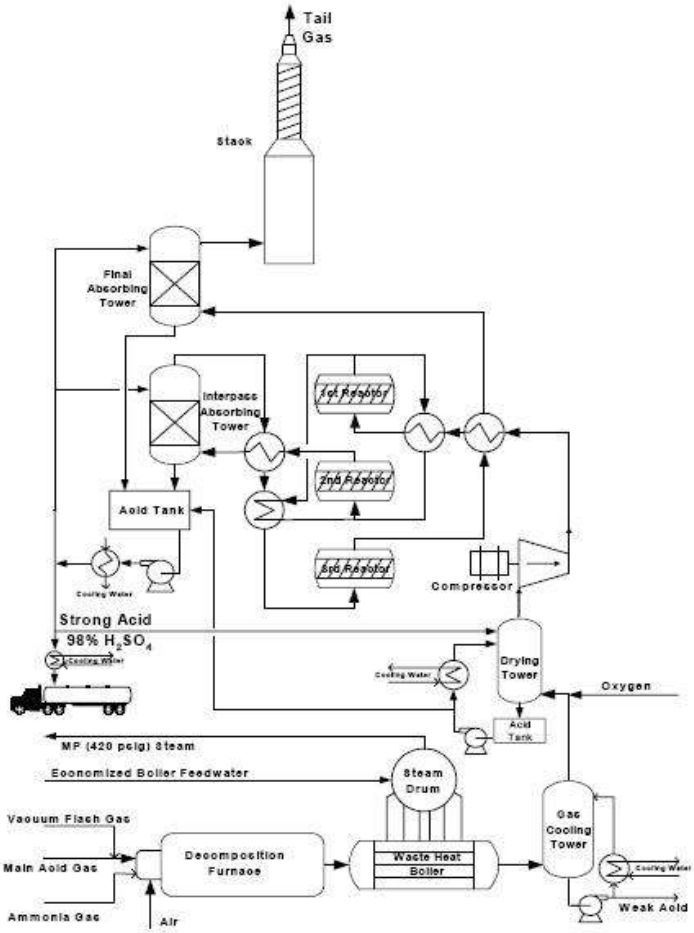

Fig. 7 – Tampa Electric IGCC Sulfuric Acid Plan Flow Diagram

NOTE:
Coal gasification processes can produce three types of ash: fly ash (including char or unreacted fuel), bottom ash, and slag, with most of the solid by-product ending in form of slag for high-temperature gasifiers. Non-slagging gasification produces a coarse bottom ash and fine fly ash. While the amount of fly ash varies according to the type of gasification process, it is often recycled to consume the char and minimize the quantity of fly ash produced. Therefore, the ratio of slag or bottom ash to fly ash is usually much higher in IGCC plants than it is in combustion-based plants in any case.

By-products Evaluation

All the residues generated from this **10 MWh IGCC** power plant constitute the main by-products (commodities) with defined international markets. Off-course, the collection, treatment, disposal and packaging of these commodities require additional technologies and space, which therefore increase the cost of the power plant. However, the integration of these advanced and progressive technologies adds values to project, making it more **technoeconomically and environmentally viable**.

Table 9: Daily input and output values from various IGCC plants

IGCC Plant	Capacity [MWh]	Coal (MT/d)	Slag (MT/d)	Char [MT/d]	Particulates [MT/d]	Sulphure [MT/d]
	10	x	x	x	x	x

Integrated Wastewater Treatment Plant

The power plant shall be provided with its own integrated Wastewater Treatment Plant (WTP) for the collection, treatment and reuse of the liquid wastes generated from the Gasifier (which is water intensive, cca. 50% of the quantity of water used in conventional coal power plant or coal-fired power plant) and from the combustion Gensets and Turbine.

The **liquid wastes** include Gasifiers blowdown, Boiler blowdown, Cooling Tower blowdown, acid and caustic water treating wastes, coal pile runoff, and various contaminated wastes from chemical storage areas, sanitary sewage and yard areas. These liquid wastes are also produced from the internal combustion Genset and Turbine generating station that will be disposed of as follows: Miscellaneous oily wastes from storage tank areas and sumps will be directed to an API separator. Supplementary treating can be utilized if necessary to meet the applicable requirements for wastewater discharge.

The clean water produced by the Wastewater Treatment Plant shall be used for the **gasification** and for the **cooling the Genset and Turbines**. The required quality specifications of the water are provided in **1.2.1.2** below (Water Supply).

NOTE:
both solid and liquid wastes will be handled and disposed of in an environmentally acceptable manner. For plants of size less than 1,000kW, liquid oily wastes will be accumulated in sumps or small tanks for removal. Residues from filters and centrifuges will be similarly handled.

5.5.5 Environmental Considerations

Environmental considerations include noise control and aesthetic treatment of the project. The final location of the project within the site area will be reviewed in relation to its proximity to hospital and office areas and the civilian neighbourhood, if applicable. Also, the general architectural design will be reviewed in terms of coordination and blending with the style of surrounding buildings. Any anticipated noise or aesthetics problem will be resolved prior to the time that final site selection is approved.

5.5.6 Economic considerations

a) The selection of one particular type of design for a given application, when two or more types of design are known to be feasible, will be based on the results of an

economic study in accordance with the technical, financial and legal requirements and local and international regulations.

b) The EU and International Standards for economic studies shall be applied. For instance, in the US, the applicable international Standards for economic studies are contained in AR 11-28 and AFR 178-1, respectively. Additional standards for design applications dealing with energy/fuel consuming elements of a facility are contained in the US Code of Federal Regulations, 20 CFR 436A. Clarification of the basic standards and guidelines for a particular application and supplementary standards, which may be required for special cases may be obtained through normal channels from HQDA (DAEN-ECE-D), WASH DC 20314.

6 SITE SELECTION AND CIVIL FACILITIES DESIGN AND CONSTRUCTION

6.1 SITE SELECTION

Since the selection of a site has a significant influence on the design, construction and operating costs of a power plant, we have proposed to choose a potential plant site as shown in Fig 1-2 above due to its strategic location and accessibility. The external connections and deliveries of goods and services shall be direct and not through the premisses of the Free Trade Zone. The Operation of the Power Plant should not disturb or obstruct other business activities within the Free Trade Zone. It should not also encumber the environment of the Free Trade Zone. The power plant shall be implemented in an area of **3ha (30,000 m^2)**. Its real construction dimensions are: **160 m x 100 m** (**16,000 m^2)**.

As already stated above, the Power Plant shall be implemented as an embedded power generation for the Enpower Free Trade Zone (EFTZ), which is located just at the periphery of the Enugu City (9th Mile Corner). The site is provided with very good standards access roads and highways. The underground water of the area does not need any further treatment. It is said to be one of the cleanest underground water in the world (*source*: UN World Food Program). The terrain is very plan, without hills and valleys. A stream is running across the lower side of the Plant. Due to environmental concerns, the underground water shall not be used is only reserve for human consumption and shall not be contaminated by the plant operation. Because of the quality and quantity of the underground water, the Heineken Brewery in Nigeria is located in that area.

6.1.1 Physical characteristics

Selection of the site will be based on the availability of usable land for the plant, including yard structures, fuel handling facilities, and any future expansion. Other considerations that will be taken into account in site selection are:

- Soil information;
- Site drainage;
- Wind data;
- Seismic zone; and
- Ingress and egress.

For economic purposes and operational efficiency, the plant site will be located as close to the load centre as environmental conditions permit.

6.1.2 Soil investigation

An analysis of existing soils conditions will be made to determine the proper type of foundation. Soils data will include elevation of each boring, water table level, description of soil strata including the group symbol based on the Unified Soil Classification System, and penetration data (blow count). The soils report will include recommendations as to type of foundations for various purposes; excavation, de- watering and fill procedures; and suitability of onsite material for fill and earthen dikes including data on soft and organic materials, rock and other pertinent information as applicable. **The project Company, XENERGI LTD, shall issue the Soil Test Data, based on which the Civil Engineering Company, EUROMADE ENGINEERING & CONSTRUCTION LIMITED (EUMEC) shall developed the foundation to meet the foundation installation requirements of the technologies (Gasifier, Boiler and Genset)**.

6.1.3 Site development

Grading and drainage.

1) **Basic criteria**. Determination of final grading and drainage scheme for a new power plant will be based on a number of considerations including size of property in relationship to the size of plant facilities, desirable location on site, and plant access based on topography. If the power plant is part of an overall complex, the grading and drainage will be compatible and integrated with the rest of the complex. To minimize cut and fill, plant facilities will be located on high ground and storm water drainage will be directed away from the plant. Assuming on site soils are suitable, grading should be based on balanced cut and fill volume to avoid hauling of excess fill material to offsite disposal and replacement with expensive new material.

2) **Drainage.** Storm water drainage will be evaluated based on rainfall intensities, runoff characteristics of soil, facilities for receiving storm water discharge, and local regulations. Storm water drains or systems will not be integrated with sanitary drains and other contaminated water drainage systems.

3) **Erosion prevention.** All graded areas will be stabilized to control erosion by designing shallow slopes to the greatest extent possible and by means of soil stabilization such as seeding, sod, stone, rip-rap and retaining walls.

4) **Roadways.**
   a) **Basic roadway requirements**. Layout of plant roadways will be based on volume and type of traffic, speed, and traffic patterns. Type of traffic or vehicle functions for power plants can be categorized as follows:
      - Passenger cars for plant personnel;
      - Passenger cars for visitors;
      - Trucks for maintenance material deliveries;
      - Trucks for fuel supply; and

- Trucks for removal of ash, sludge and other waste materials.

b) **Roadway material and width.** Aside from temporary construction roads, the last two categories described above will govern most roadway design, particularly if the plant is coal fired. Roadway material and thickness will be based on economic evaluations of feasible alternatives. Vehicular parking for plant personnel and visitors will be located in areas that will not interfere with the safe operation of the plant. Turning radii will be adequate to handle all vehicle categories. Refer to TM 5-803-5/ NAVPAC P-960/AFM 88-43; TM 5-818-2/ AFM 88-6, Chap. 4; TM 5-822-2/AFM 88-7, Chap.7; TM 5-822-4/AFM 88-7, Chap. 4; TM 5-822 -5/AFM 88-7, Chap. 3; TM 5-822-6/AFM 88-7, Chap. 1; TM 5-822-7/AFM 88-6, Chap. 8; and TM 5-822-8.

c) **Railroads.** If a railroad spur is selected to handle fuel supplies and material and equipment deliveries during construction or plant expansion, the design will be in accordance with American Railway Engineering Association standards. If coal is the fuel, spur layout will accommodate coal-handling facilities including a storage track for empty cars or by using convey belt from coal mine site to power plat site depending on the distance. If liquid fuel is to be handled, unloading pumps and steam connections for tank car heaters may be required in frigid climates.

6.1.4 Economics

Where the choice of several sites exists, the final selection was based on economics and engineering studies.

6.2 CIVIL FACILITIES DESIGN AND CONSTRUCTION

The safety design features of the facility described in the following paragraphs will be incorporated into the power plant design to assist in maintaining a high level of personnel safety and security.

6.2.1 Design safety and security features

In designing a power plant, the following general recommendations on safety will be given attention:

1) Equipment will be arranged with adequate access space for operation and for maintenance. Wherever possible, auxiliary equipment will be arranged for maintenance handling by the main Steam Turbine Hall Crane. Where this is not feasible, monorails, wheeled trucks, or portable A-frames should be provided if disassembly of heavy pieces is required for maintenance.

2) Safety guards will be provided on moving parts of all equipment.

3) All valves, specialties, and devices needing manipulation by operators will be accessible without ladders, and preferably without using chain wheels. This can be

achieved by careful piping design, but some access platforms or remote mechanical operators may be necessary.

4) Impact type handwheels will be used for high-pressure valves and all large valves.

5) Valve centres will be mounted approximately **7 ft (2.134 m)** above floors and platforms so that rising stems and bottom rims of handwheels will not be a hazard.

6) Stairs with conventional riser-tread proportions will be used. Vertical ladders, installed only as a last resort, must have a safety cage if required by the Occupational Safety and Health Act (OSHA).

7) All floors, gratings and checkered plates will have non-slip surfaces.

8) No platform or walkway will be less than **3 ft (0.914 m)** wide.

9) Toe plates, fitted closely to the edge of all floor openings, platforms and stairways, will be provided in all cases.

10) Adequate piping and equipment drains to waste will be provided.

11) All floors subject to washdown or leaks will be sloped to floor drains.

12) All areas subject to lube oil or chemical spills will be provided with curbs and drains.

13) If plant is of semi-outdoor or outdoor construction in a climate subject to freezing weather, weather protection will be provided for critical operating and maintenance areas such as the firing aisle, boiler steam drum ends and soot blower locations.

14) Adequate illumination will be provided throughout the plant. Illumination will comply with requirements of the Illuminating Engineers Society (IES) Lighting Handbook, as implemented by DOD 4270.1-M.

15) Comfort air conditioning will be provided throughout control rooms, laboratories, offices and similar spaces where operating and maintenance personnel spend considerable time.

16) Mechanical supply and exhaust ventilation will be provided for all of the power plant equipment areas to alleviate operator fatigue and prevent accumulation of fumes and dust. Supply will be ducted to direct air to the lowest level of the power plant and to areas with large heat release such as the turbine or engine room and the boiler feed pump area. Evaporative cooling will be considered in low humidity areas. Ventilation air will be filtered and heated in the winter also, system air flow capacity should be capable of being reduced in the winter. Battery room will have separate exhaust fans to remove hydrogen emitted by batteries as covered in TM 5-811-2/AFM 88-9, Chap. 2.

17) Noise level will be reduced to at least the recommended maximum levels of OSHA. Use of fan silencers, compressor silencers, mufflers on internal combustion

engines, and acoustical material is required as discussed in TM 5-805-4/AFM 88-37/NAVFAC DM-3.1O and TM 5-805-9/AFM 88-20/NAVFAC DM-3.14. Consideration should be given to locating forced draft fans in acoustically treated fan rooms since they are usually the largest noise source in a power plant. Control valves will be designed to limit noise emissions.

18) A central vacuum cleaning system should be considered to permit easy maintenance of plant.

19) Colour schemes will be psychologically restful except where danger must be highlighted with special bright primary colours.

20) Each equipment item will be clearly labelled in block letters identifying it both by equipment item number and name. A complete, coordinated system of pipe markers will be used for identification of each separate cycle and power plant service system. All switches, controls, and devices on all control panels will be labelled using the identical names shown on equipment or remote devices being controlled.

6.2.2 Size and arrangement of the Civil Facilities

Main building size and arrangement depend on the selected plant equipment and facilities including whether Steam Turbines (STs) are indoor or outdoor type; source of cooling water supply relative to the plant; the relationship of the switchyard to the plant; provisions for future expansion; and, aesthetic and environmental considerations. Generally, the main building will consist of a Steam Turbines bay with traveling crane; an auxiliary bay for feedwater heaters, Condensers, pumps, and switchgear; (or firing aisle for semi-outdoor units); and general spaces as may be required for machine shop, locker room, laboratory and office facilities. The general spaces will be located in an area that will not interfere with future plant expansion and isolated from main plant facilities to control noise. For very mild climates the turbine generator sets and steam generators may be outdoor type (in a weather protected, walk-in enclosure) although this arrangement presents special maintenance problems.

Architectural treatment.

The basic requirements are considered as follow:

a) The architectural treatment will be developed to harmonize with the site conditions, both natural and manmade. Depending on location, the environmental compatibility y may be the determining factor. In other cases the climate or user preference, tempered with aesthetic and economic factors, will dictate architectural treatment. Climate is a controlling factor in whether or not a total or partial closure is selected. Semi-outdoor construction with the bulk of the steam generator not enclosed in a boiler room is an acceptable design.

b) For special circumstances, such as areas where extended periods of very high humidity, frequently combined with desert conditions giving rise to heavy dust

and sand blasting action, indoor construction with pressurized ventilation will be required not only for the main building but also, generally, for the switchyard.

c) Control rooms (located close to the Steam Turbine Hall), offices, locker rooms, and some outbuildings will be enclosed regardless of enclosure selected for main building. Circulating water pumps may be installed in the open, except in the most severe climates. For semi-outdoor or outdoor stations, enclosures for switchgear and motor controls for the auxiliary power system will be enclosed in manufacturer supplied walk-in metal housings or site fabricated closures.

Structural design

a) **Building framing and turbine pedestals**. Thermal stations will be designed utilizing conventional structural steel for the main power station building and support of boiler. The pedestal for supporting the turbine generator (and turbine driven boiler feed pump if utilized) will be of reinforced concrete. Reinforced concrete on masonry construction may be used for the building framing *(not* for boiler framing); special concrete inserts or other provision must be made in such event for support of piping, trays and conduits. An economic evaluation will be made of these alternatives.

b) **Exterior walls.** The exterior walls of most thermal power stations are constructed of insulated metal panels. However, concrete blocks, bricks, or other material may be used depending on the aesthetics and economics of the design.

c) **Interior walls.** Concrete masonry blocks will be used for interior walls; however, some specialized areas, such as for the control room enclosure and for offices, may utilize factory fabricated metal walls, fixed or moveable according to the application.

d) **Roof decks.** Main building roof decks will be constructed of reinforced concrete or ribbed metal deck with built-up multiply roofing to provide waterproofing. Roofs will be sloped a minimum of 1/4 inch per foot for drainage.

e) **Floors.** Except where grating or checkered plate is required for access or ventilation, all floors will be designed for reinforced concrete with a non-slip finish.

f) **Live loads.** Buildings, structures and all portions thereof will be designed and constructed to support all live and dead loads without exceeding the allowable stresses of the selected materials in the structural members and connections. Typical live loads for power plant floors are as follows:
- Turbine generator floor 500 psf;
- Basement and operating floors except turbine generator floor;
- Mezzanine, deaerator, and miscellaneous operating floors; and
- Offices, laboratories, instrument shops, and other lightly loaded areas Live loads for actual design will be carefully reviewed for any special conditions and actual loads applicable.

g) **Other loads.** In addition to the live and dead loads, the following loadings will be provided for:
   - **Wind loading.** Building will be designed to resist the horizontal wind pressure available for the site on all surfaces exposed to the wind.
   - **Seismic loading.** Buildings and other structures will be designed to resist seismic loading in accordance with the zone in which the building is located.
   - **Equipment loading.** Equipment loads are furnished by the various manufacturers of each equipment item. In addition to equipment dead loads, impact loads, short circuit forces for generators, and other pertinent special loads prescribed by the equipment function or requirements will be included.

Foundation design

a) Foundations is designed to safely support all structures, considering type of foundation and allowable bearing pressures. The two most *com*mon types of foundations are spread footings and pile type foundations, although "raft" type of other special approaches may be utilized for unusual circumstances.

b) Pile type foundations require reinforced concrete pile caps and a system of reinforced concrete beams to tie the caps together. Pile load capabilities may be developed either in friction or point bearing. The allowable load on piles will be determined by an approved formula or by a load test. Piles can be timber, concrete, rolled structural steel shape, steel pipe, or steel pipe concrete filled.

c) Design of the reinforced concrete turbine generator or diesel set foundation, both mat and pedestal, will be such that the foundation is isolated from the main building foundations and structures by expansion joint material placed around its perimeter. The design also ensures that the resonance of the foundation at operating speed is avoided in order to prevent cracking of the foundation and damage to machines caused by resonant vibration. The foundation is designed on the basis of deflection. The limits of deflection are selected to avoid values of natural frequency by at least 30% above or 30% below operating speed.

d) Vibration mounts or "floating floor" foundations where equipment or equipment foundation inertia blocks are separated from the main building floor by springs or pre-compressed material will generally not be used in power plants except for ventilation fans and other building service equipment. In these circumstances where such inertia blocks are considered necessary for equipment not normally so mounted, written justification will be included in the project design analysis supporting such a necessity. **The location of Turbine Generators, Gas/Dual Fuel Gensets, Boiler Feed Pumps, Draft Fans, Compressors, and other high speed rotating equipment on elevated floors will be avoided because of the difficulty or impossibility of isolating equipment foundations from the building structure.**

6.2.3 The Project Main Civil Facilities

Fig. 8 – Plant Panoramic Front View

Fig. 9 – Plant Panoramic Right View

Fig. 10 – Plant Panoramic Left View

The main Civil Facilities (CFs) consist of followings (Fig. 1-10 below), showing the plant layout with the full Civil Facilities /Objects for the 60MWh IGCC Power and for the actual **10MWh IGCC Power** Plant indicating in **red dashed lines** in Fig. 10. Below:

1) CF1 – Access roads external and internal roads)
2) CF2 – Main entrance and security post
3) CF3 – Administration and operations management building
4) CF4 – Coal receiving, storage and handling facilities
5) CF5 – Storeroom and maintenance workshop
6) CF6 – Wastewater treatment plant
7) CF7 – Powerhouse
8) CF8 – Stacks / Exhaust ducts
9) CF9 – 1 x raw water tank and 2 x clean water storage tanks (concrete)
10) CF10 – 3 x cooling water tanks
11) CF11 – Gas supply tanks
12) CF12 – Power generation and distribution control room
13) CF13 – Coal gasifier

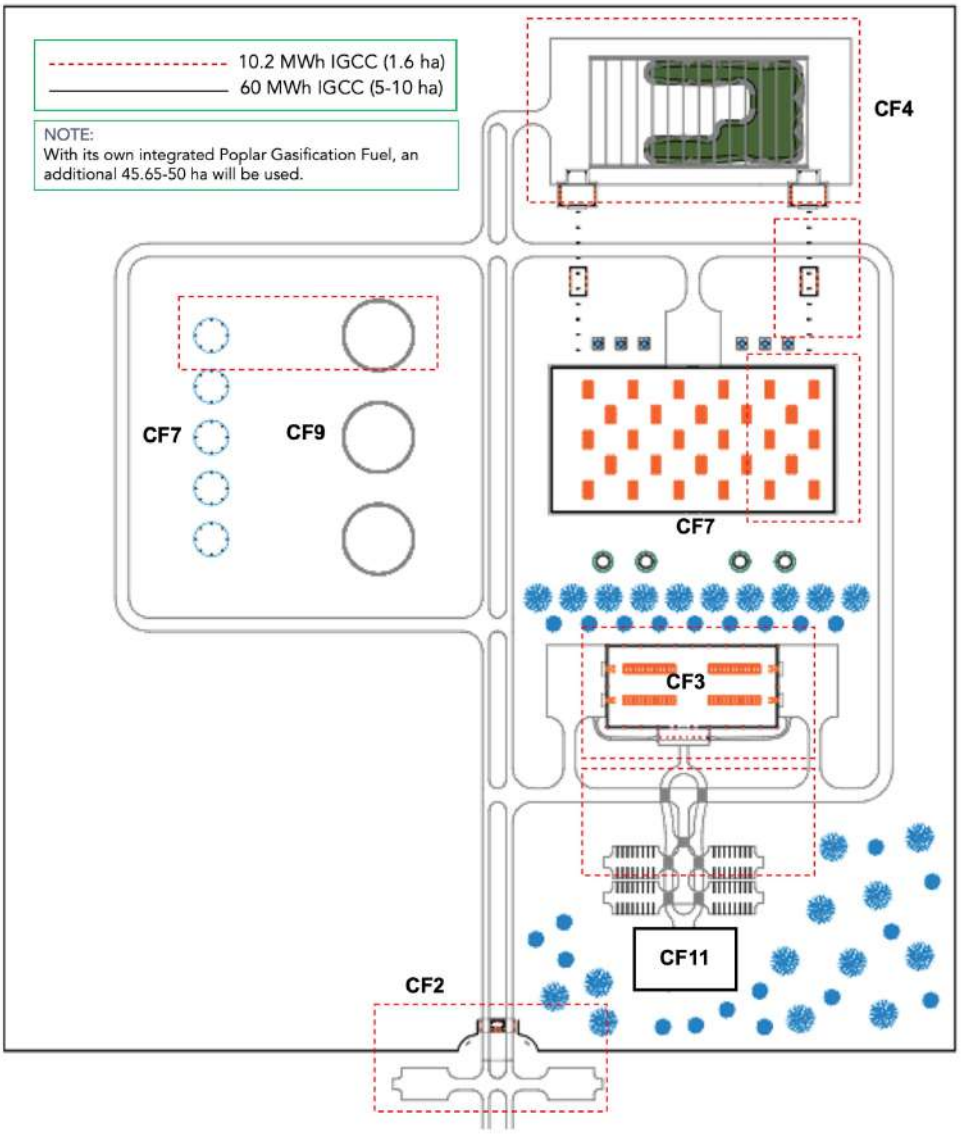

Fig. 11 – Plant construction site layout (2D Top View)

6.2.4 Description of the Main Civil Facilities

CF1 – Access roads (external and internal roads)

The Power Plant shall be provided with high quality standard internal roads, which shall be designed for heavy-duty equipment and the transportation of heavy technologies up to 100 tons.

The external and internal access of the plant shall be provided in accordance with the international system of roadways, consisting of three types of roads: Type I, Type II and Type III, provided as follow:

1) **Type I roads** shall consist of one **10.0 m** wide asphalt paved carriageways with 1.5 m wide hard shoulders. The main plant access roads of a two-lane roads (entrance and exit) and a portion of the main plant complex circumferential road shall be Type I.

2) **Type II roads** shall be **4.5 m** wide with **1.5 m** wide hard shoulders on either side.

3) **Type III roads** shall be provided along the plant boundary for access for security and maintenance.

All roads shall be surfaced with gravel during the construction period. Occasional applications of a dust palliative material shall be used to minimize the dust problem during the dry seasons.

All Type I and Type II roads shall have a minimum turning radius of **15.2 m**. Bollards shall be provided alongside all type roadways near equipment which requires protection. Spare duct banks shall be provided under all type roads spaced at **100 m** intervals.

CF2 – Main entrance and security post

As provided in Figures 8 and 11, the Main Entrance Security Post has One (1) main section, called the Main or Central Security Post of the Power Plant of the following dimensions: **12 m x 5 m x 12 m (60 m^2)**. The security post shall be provided with its own locker room located at the first floor. The security shall be responsible for the surveillance and security of the whole power plant and its surroundings, including parking areas. Visitors' cars are not allowed to enter the premisses of the plant. Visitor's Parking areas are located just at the main gate and very close to the security post to enable a regular registry and strict control of the visitors. The central security post shall be provided with modern monitoring systems capable of detecting radioactive and toxic materials of the supplied coal. All the lorries or trucks and theirs content shall be weighted and screened at the main entrance before and before they are allowed to enter the plant.

The security post shall also be provided with:

- One (1) advanced CCTV, monitoring all the premisses and the plant surroundings. The main security post shall have a CCTV of LG ultrawide monitor (LG 49WL95C) provided with loads of connectivity, a super-high resolution, and HDR.

- Two (2) closets, Two (2) steel tables and with drawers and two office chairs.

- Its own locker room for all the security guaranty guards on duty. The locker room shall be located on the upper floor with toilets. The lower or ground floor or operation office shall be provided with a small semi-detached eatery **(4 m x 4 m)** for coffee, tea breaks and supper.

CF1 – CF3 – Administration and operations management building

The Administration Building and Operations Management Building (**25 m x 20 m x 12 m**) is a modern 1-floor complex (*i.e*. ground floor and first floor building) provided with the followings:

- **Building reception:** at the ground floor provided with reception desk, waiting rooms and TV, showing the plant activities, including daily and historical productions information and data.

- **First Floor:** Six (6) offices, One (1) Rest Room and One (1) Kitchen.

- **Ground Floor:** Four (4) offices, One (1) Conference Room and One (1) visitors' Rest Room.

CF4 – Coal receiving, storage and handling facilities

- **Coal receiving and storage area:** Four underground coal hoppers are set to receive coal from the covered coal area. The hopper is reversed pyramidal shape. Under the outlets of hopper, four GK type-vibrating feeders will be installed. The dimensions of the Coal Storage Area are **35 m x 26 m x 15.00 m**. Its area is **910 m^2**. This Storage Facility is a capacity of storing a minimum quantity of **9,500 MT** of coal, which represent a storage capacity of cca. **40 days**.

- **Crushing facility:** Crushing facility is located in the belt conveying system. One stage crusher is used for the plant. Two crushing plant will be provided for coal processing, one operating, one standby, and the possibility for operating simultaneous will be considered.

  The oversized coal will go to the crusher to be crushed into the required size of coal boilers. The capacity of coal crusher **of an adjustable capacity of 30-40 t/h** for a **Gasifier of a capacity of 25-30 t/h**. The crushed coal supply to the Gasifier is directly supplied from

  The Total capacity of the crushing and silo filling system for the Three Units is determined on the basis of the daily maximum burn rate for the Three Units times approximately **2.4.** This ***service factor*** allows for maintenance and flexibility of operation, requiring approximately 10 hrs. per day to supply the units with 24/7 worth Coal. The conveyor path usual shall consist of dual conveyors with each conveyor handling half of the total capacity (1.2 time maximum gasification rate). The use of dual units securer full capacity, even with one (1) conveyor out of service for maintenance or repair.

The total average gasification rate of **27.90** tons per hour (tph) will have the following silo filling system. The system will handle: 27.5 tph x 1.2 = **33 tph** (for filling system from the silo of the crushed coal).

- **Belt conveying system:** The Bet Conveying System shall be provided with a standby to back up the coal supply to Gasifier and secure the coal reclaim system.

  Plough strippers will be used on the gasifier bunker to unload coal from the belt conveyor to the gasifier bunker.

- **Block separator:** One Block Separator will be installed in the **No.1 transfer tower**.

  The Plant is provided with a Block Separator to protect the coal handling system from damage by any extraneous material delivered in the coal, including wood logs, bricks, large metal items and other contaminants.

CF5 – Storeroom and maintenance workshop

The Power Plant Storeroom and Maintenance Workshop shall be located in the same Building (CF5), separated by a Glass Wall.

- **Storeroom:** The Storeroom is the room in which the spare parts, accessory technologies and equipment are stored. The storeroom shall be kept under required temperature and standard, preventing the contact of the aforementioned items with dust. The dimensions of the storeroom are **30 m x 25 m x 12 m**. Delivery Trucks can directly get access in the store as shown in Figure 11 above.

- **Maintenance workshop:** The Maintenance Workshop of the power plant shall be provided with the area of **300 m^2 (30 m x 10 m x 12 m)** and an asphalted outdoor area of **800 m^2**, where heavy-duty and large-sized equipment are temporary kept (i.e. at the backside of the Storeroom). All the working tools requirement for the maintenance of the plant equipment are kept in the workshop.

CF6 – Wastewater treatment plant

Besides, the raw water collected or piped directly from Oji river, the onsite water treatment facility treats all runoff, cleaning wastes, blowdown, and backwash to within the International and Nigerian EPA standards for suspended solids, oil and grease, pH, and miscellaneous metals. Waste treatment equipment is housed in a separate semi-detached building to the **Powerhouse**. It total Product Capacity is **100 m^3/hr**. The waste treatment system consists of a water collection basin, three raw waste pumps, an acid neutralization system, an oxidation system, flocculation, clarification/thickening, and sludge dewatering. The water collection basin is a synthetic-membrane-lined earthen basin, which collects rainfall runoff, maintenance cleaning wastes, and backwash flows.

The raw waste is pumped to the treatment system at a controlled rate by the raw waste pumps. The neutralization system neutralizes the acidic wastewater with hydrated lime in a two-stage system, consisting of a lime storage silo/lime slurry makeup system, dry lime feeder, lime slurry tank, slurry tank mixer, and lime slurry feed pumps.

The oxidation system consists of an air compressor, which injects air through a sparger pipe into the second-stage neutralization tank. The flocculation tank is fiberglass with a variable speed agitator. A polymer dilution and feed system is also provided for flocculation. The clarifier is a plate-type, with the sludge pumped to the dewatering system. The sludge is dewatered in filter presses and disposed offsite. Trucking and disposal costs are included in the cost estimate. The filtrate from the sludge dewatering is returned to the raw waste sump.

CF7 – Powerhouse

The Powerhouse shall contain all the power generating technologies and equipment in its area of **980 m^2** (**35 m x 28 m x 12.00 m**). The distance between the Powerhouse walls and Gensets and Steam Turbine, installed side by side, shall be **5 m** in order to ease the movement of large and heavy equipment and people during scheduled, unscheduled and periodic maintenances. For the same purpose, the distance, the distance between Gensets and Turbine shall also be **5 m**. The main components and equipment of the powerhouse are:

- Gensets
- Steam Turbine
- Generator
- Powerhouse Crane
- Cooling Water Pump
- Technical Team Office, and Control Room

CF8 – Stacks / Exhaust ducts

The Plant can be provided with one (1) stack with a single fiberglass-reinforced plastic (FRP) liner instead of three (3) as provided in Figures 8, 9, 10 and 11 above. The stack is constructed of reinforced concrete. The stack is **30 m** high for adequate particulate dispersion.

CF9 – 1 x raw and 2 x clean water storage tanks (concrete)

The Power plant has three (3) concrete water tanks WT1, WT2, and WT3. WT1 is the raw water tank while WT2 and WT3 are the clean water tanks, which shall be used for the gasification, cooling, consumption and other usages within the plant. The standard dimensions of the Tanks are provided in the table 1-6 below. WT2 shall be used for potable water supply to the power plant, and extra water shall be supplied to the distribution system of the Free Trade Zone. WT3 is used to store the water required for the gasification.

Table 10: Standard Dimensions of the Water Tanks

Tank Capacity [L]	Tank Capacity [Gal]	External Diameter [m]	External Height [m]	Site Hole/Diameter [m]
4,000,000	1,056,688	30.5	6.0	33.0

The clean water storage capacity of the is **8,000 m^3** and the raw water storage capacity is **4,000 m^3**. This Quantity is enough for the sustainable operation of the plant 24/7. The

power plant also may sell child potable water to the all the free trade companies and generated extra incomes. **The potable water by is also a by-product of the power plant**.

NOTE:

- *Tank Height includes a **350mm Riser** on top.*
- *Heights include a standard roof. Heavier roofs increase the height*
- *Measurements above are an external measurement*

CF11 – 1 x cooling water tanks

The cooling water shall be treated to meet the quality provided in table 1-9 below.

Table 11: Cooling water / coolant for the cooling circuit

Parameters	Value
pH value at 25 °C	9 to 10.5
Electrical conductivity	less than 0.1 mS/cm
Oxygen (O_2)	less than 0.05 mg/L
Chloride	less than 20 mg/L
Copper (Cu)	less than 0.05 mg/L
Total iron (Fe)	less than 0.05 mg/L
Earth alkalis	5 to 10 mg/L
Total hardness	less than 0.02 mmol/L

- **Cooling technologies:** One of the main inputs for the 10MWh IGCC power plant is water, which is used for the gasification and for cooling the power plant and for consumption in order to keep the power plant operating sustainably. As a thermoelectric plant, the cooling system of this power plant withdraws water and evaporate it to condense the steam back to a liquid for pumping and efficiency purposes.

  There are two widely implemented types and one seldom used type of cooling for power production. The **two major types** are **once-through cooling** and **closed-loop cooling**; the **minor type** is termed **dry cooling**. Dry cooling is typically more water efficient, both from a capital cost and an operational cost because **dry cooling** uses **little** or **no water** and needs less maintenance than cooling towers that require water. **Dry cooling will not be considered in the design of the cooling system of this power plant**.

- **Once-Through Cooling:** Once-through cooling systems use the nearby water to help cool the condenser water. The **river** or **lake water** is passed through a heat exchanger to condense the steam. The exiting condenser water is pumped back through the cycle and the river water is returned to the stream (Figure 12). The water consumption at the power plant is minimal, if not zero, because the water does not directly contact the air. However, the temperature increase of the river water increases the evaporation rate, thus indirectly increasing the amount of water consumption. Although the consumptive water use is minimal, the amount of water withdrawn from the river is significant because the water is only used for a short time before it is returned to the stream.

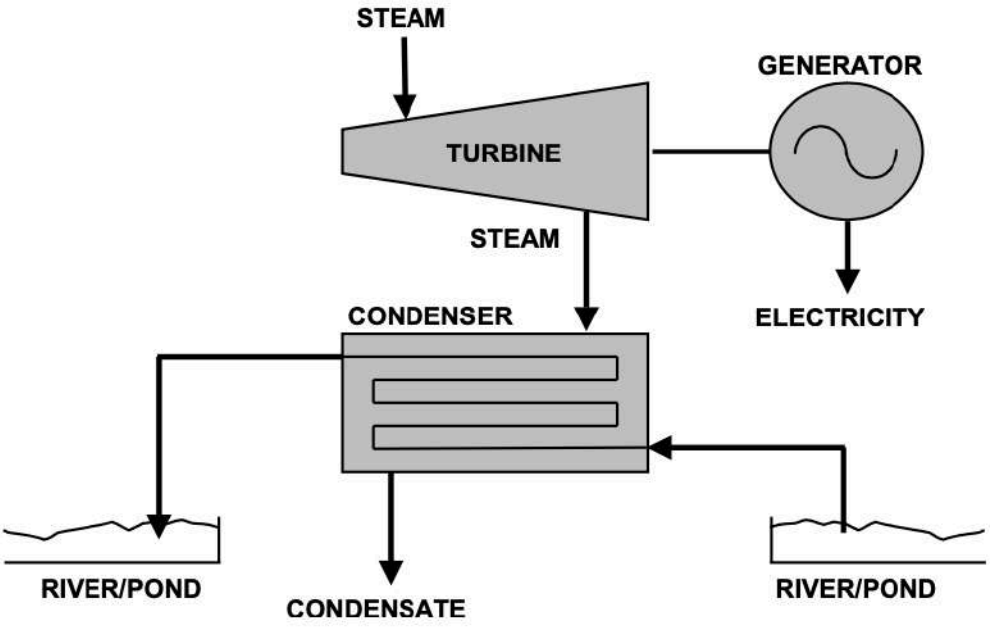

Fig. 12 – Once-trough cooling system

If the plant has a once through cooling system, the following will be determined:

1) The limitations established by the appropriate regulatory bodies, which must be met to obtain a permit required to discharge heated water to the source.

2) Maximum allowable temperature rise permissible as compared to system design parameters. If system design temperature rise exceeds permissible rise, a supplemental cooling system (cooling tower or spray pond) must be incorporated into the design.

3) Maximum allowable temperature for river or lake after mixing of cooling system effluent with source. If mixed temperature is higher than allowable temperature, a supplemental cooling system must be added. It is possible to meet the conditions of point 2. above and not meet the conditions in this subparagraph.

4) If extensive or repetitive dredging of waterway will be necessary for plant operations.

5) The historical maximum and minimum water level and flow readings. Check to see that adequate water supply is available at minimum flow and if site will flood at high level.

- **Closed-Loop Cooling:** A closed-loop cooling system can be designed to minimize the amount of water withdrawn from the river. In this system, the condenser water still exchanges heat with water in a heat exchanger, but the cooling water is recycled between a cooling tower and a heat exchanger (Figure 13). In this system, the cooling water is cooled by evaporating a percentage of the water to the environment. Because the water is evaporated, there has to be a make-up water supply to account for the consumed water. The make-up water typically comes from the nearby water source. This system consumes much more water than once-

through types because the entire energy exchange is through evaporation of the water (a consumptive use). These systems withdraw less water because the only water used is to make up the evaporated portion; however, they consume more water.

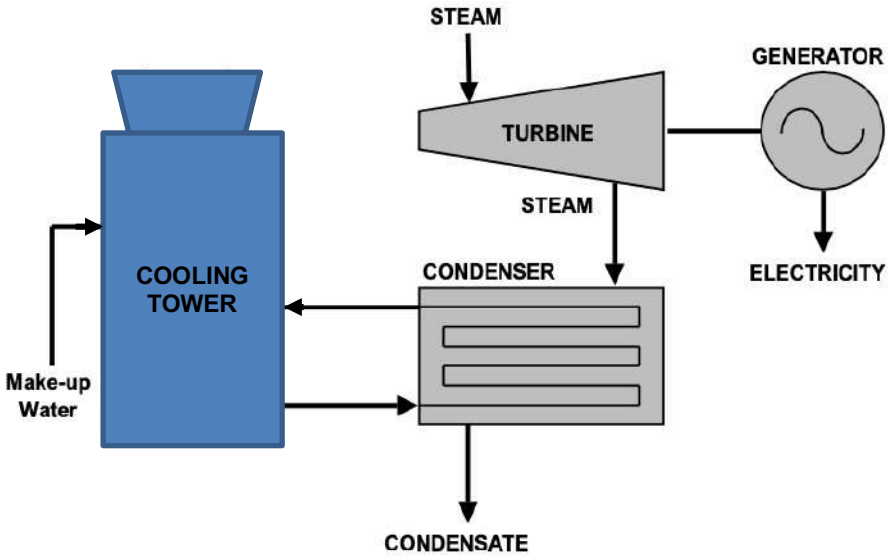

Fig. 13 – Closed-loop cooling system

CF12 – Gas Storage Tanks

The Five (5) Gas Storage Tanks (GST1, GST2, GST3, GST4, and GST5) are required for the storage of the Syngas generated from Gasifiers. Each Genset has its own Gas Supply Tanks (GST1 and GST2). The other three (3) Gas Storage Tanks contain the reserved Syngas continually generated from the Gasifier in the case of scheduled and unscheduled maintenance of the Gasifier or coal or water outages. The reserved quantity of gas in one tank is enough the keep the Genset of 3.333 MWh running for at least five (5) without fuel supply. Hence, the total reserve can keep the power plant running for a period of at 14 days (2 weeks). The internal radius of the tanks is **8.95 m**.

The standard dimensions of the Gas Storage Tanks are provided in the table 1-9 below.

Table 12: Standard Dimensions of the Gas Storage Tanks

Parameters	Unit /Standard	Value
Capacity	m^3	3,000
Weight	kg	636,868
Full Load Weight	T	2,330
Outer Material	SA-537M Cl.2	-
Inner Material	SA-537M Cl.2	-
Maximum Working Pressure	MPa	1.8
Working Temperature	°C	-34 to 40
Design Temperature	°C	-20 to 50
Standard	ASME BV	-
Colour	White	-
Hydraulic test	MPa	2,484
Air tightness test	MPa	1,737

CF13 – Power Generation and Distribution Control Room

The Control Room is designed to monitor the generation and distribution capacities of the Power Plant, assuring that all the equipment, Genset, Turbine, Generator, Gasifier, Coal handling equipment and storage facilities, etc. are operating perfection without defect. All the power plant operation data, including emission limits data are monitoring and adjusted from the from control room. Any other detected mechanical or electric fault shall be announced to the technical team to fix it on site and without delay.

The Control Room, as shown in Figure 11 above, is in circular shape with a radius of 6.5 m. Its area is **132.70 m^2**. The Control Room Manager is responsible for the billing data in cooperation with the Financial Department. All the plant operation data history shall be kept in the Control Room.

CF15 – Coal gasifier

In a gasifier, coal undergoes a series of chemical and physical changes as shown in Figure 14. Each of the steps is described in more detail below. As the coal is heated most of the moisture is driven out when the particle temperature is ~ 105ºC. Drying is a rapid process and can be essentially complete when the temperature reaches ~ 300ºC (1) depending on the type of coal and heating method used.

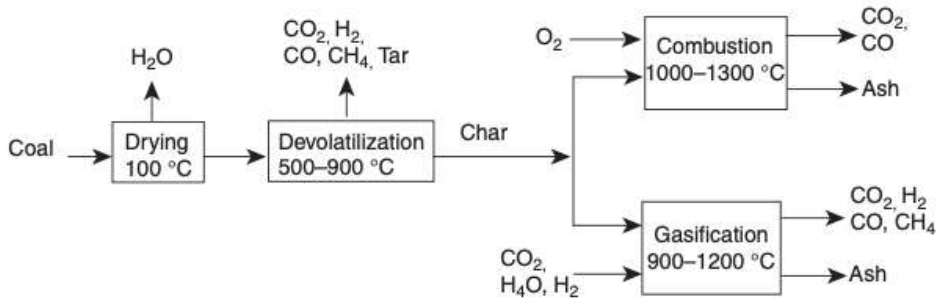

Fig. 14 – Chemical and physical changes of coal

Coal gasification is the process of reacting coal with oxygen, steam, and carbon dioxide to form a product gas containing hydrogen and carbon monoxide. Gasification is essentially incomplete combustion. The chemical and physical processes are quite similar; the main difference being the nature of the final products. From a processing point of view the main operating difference is that gasification consumes heat evolved during combustion. Under the reducing environment of gasification the sulphur in the coal is released as hydrogen sulphide rather than sulphur dioxide and the coal's nitrogen is converted mostly to ammonia rather than nitrogen oxides. These reduced forms of sulphur and nitrogen are easily isolated, captured, and utilized, and thus gasification is a clean coal technology with better environmental performance than coal combustion.

Depending on the type of gasifier and the operating conditions, gasification can be used to produce a fuel gas suitable for any number of applications. A low heating value fuel gas is produced from an air blown gasifier for use as an industrial fuel and for power production. A medium heating value fuel gas is produced from enriched oxygen blown gasification for use as a synthesis gas in the production of chemicals such as ammonia,

methanol, and transportation fuels. A high heating value gas can be produced from shifting the medium heating value product gas over catalysts to produce a substitute or Synthetic Natural Gas (SNG). Coal gasification is presented by first describing the chemistry of the process and the coal characteristics that affect the processes. Coal gasification processes have been tailored to adapt to the different types of coal feedstocks available. The development of gasification is then presented from an historical perspective. This leads into the discussion of the types of gasifiers most commonly used and the process improvements made to meet the changing market needs. Complete gasification systems are then described including typical system configuration, required system attributes, and environmental performance. The current status, economics of gasification technology, and future of gasification are also discussed.

Technology and Process – Coal gasification – and virtually all gasification of other carbon-based resources such as biomass or refinery residues – is a versatile conversion technology which adds flexibility to the energy systems. In the gasification reactors, the feedstock is converted into a synthesis gas (syngas), a **mixture of H_2, CO** and **CO_2**, which enables the production a variety of downstream energy carriers. A lot of knowledge has been gained from coal gasification worldwide as this so-called town-gas was produced from coal as early as 1792, a high-temperature **fluidized-bed gasifier** was patented in *1921 by Winkler*, and **synfuels production** from coal was common practice in Germany during World War II. According to the Gasification and Syngas Technologies Council, a trade association, there are **globally 272 operating gasification plants** with 686 gasifiers and 74 plants with **238 gasifiers under construction**. Most of them use coal as feedstock.

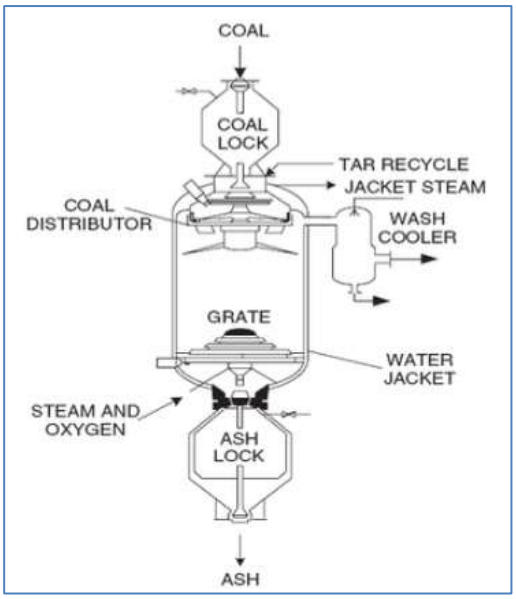

Fig. 15 – Moving Bed Gasifier concept

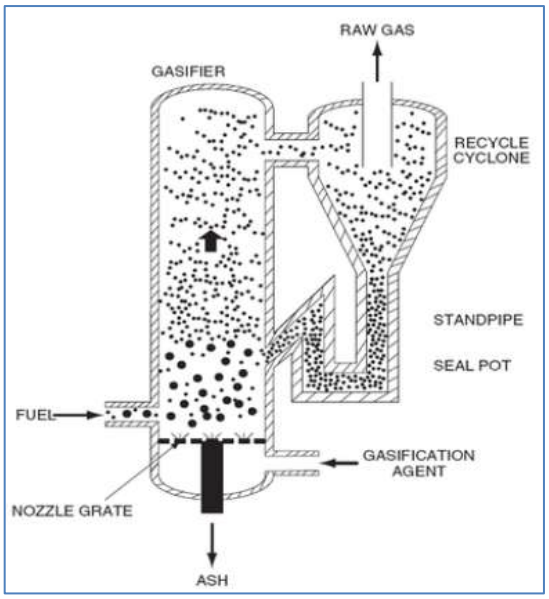

Fig. 16 – Fluidized Bed Gasifier concept

Moving-Bed Gasifier (Figure 15) – Sometimes called fixed-bed gasifier, this is the oldest gasification device in use. Lurgi developed an atmospheric reactor in 1927 and a pressurized version in 1931. It is characterized by a reaction bed where coal moves slowly downward under gravity and is gasified by a blast (in general) in counter-flow to coal. An important feature of the Lurgi dry bottom gasifier is the low consumption of oxygen and

the high steam demand. Moving-bed gasifiers need **graded coal in the range 6-50 mm**. Highly caking coals cannot be processed in moving-bed gasifiers. Mildly caking coals require the assistance of a stirrer in order to avoid the pasting-up of the bed. Tars and other oxygenated compounds are produced as by-products. An advanced variant of the original Lurgi pressure gasifier was developed jointly by British Gas and Lurgi during the 1950s and 1960s. The **British Gas/Lurgi (BGL)** slagging gasifier incorporates a molten slag bath. The much lower steam and somewhat lower oxygen consumption of the slagging gasifier results in much higher syngas production per unit of coal intake and a much lower yield of pyrolysis products compared with the dry bottom unit. Furthermore, the **CO_2 content of the gas is lower** and **the methane content is halved**.

Fluidized Bed Gasifier (Figure 16) – This device offers the advantage of promoting excellent mass and heat transfer due to the intensive mixing. On the other hand, individual particles have widely varying residence time in the bed volume. Therefore, unreacted carbon particles are inevitably removed from the bed along with fully reacted particles (ash). The best existing fluidized bed devices offer a carbon conversion of 97%. In comparison, both moving-beds and entrained-flow processes offer carbon conversions of 99%.

Entrained Flow Gasifier (Figure 17) – The advantage of entrained flow gasifiers is the ability to handle any coal feedstock and produce a clean, tar-free gas. In addition, the ash is produced in the form of inert slag or frit. This is achieved by making an additional effort in the coal preparation and high oxygen consumption, especially in the case of coal-water slurries or coals with high moisture or ash content. The majority of the coal gasification processes that have been developed after 1950 are based on entrained-flow, slagging gasifiers operating at pressures of **20 to 70 bar** and high temperatures (>1400°C).

Entrained-flow gasifiers have become the technology of choice for hard coals, and have been selected for the majority of **commercial-sized IGCC plants**. A lot of knowledge has been gained from coal gasification over several decades: town gas was manufactured from coal as early as 1792; the first process to produce methanol from syngas was installed in 1913 (**BASF**); an improved high temperature fluidized bed gasifier was patented in 1921 by Winkler; and during World War II, Germany produced large amounts of synthetic fuels from coal. Coal gasification accounted for approximately 31 GWth, with the remaining gasification plants running on petroleum, gas, petcoke, biomass and waste feedstock (NETL, 2007). A large part of the world‘s coal-based syngas is produced in 97 gasifiers in Sasol’s plants in South Africa: in 2008, an estimated conversion capacity of 14 GWth enabled the conversion of some 43 Mt/y of coal into 7,4 Mt/y of transport fuels and chemicals (Sasol, 2008). Most of the remaining coal-based syngas produced in other regions of the world is used for ammonia or methanol production, and in China, for the production of town-gas. China has become the global test case for large-scale coal conversion activities. In 2008, China held licenses from Shell for the installation of 18 coal gasification plants. Among these, 11 commercial-size coal gasification plants were already in operation, most of them for the industrial production of methanol or ammonia. Plans for the installation of further large-scale coal conversion plants include one direct liquefaction and five Fischer-Tropsch (FT) plants for liquid fuel production. While syngas is the primary product of the gasification plants, marketable products obtained from syngas include chemicals (45%), FT liquid fuels (28%), gaseous fuels (8%), and electric power (19%). In other products, gaseous fuels include synthetic natural gas (SNG). In the

IGCC power plant of the Great Plains in the US, the syngas is used to produce SNG (NETL, 2007).

While coal gasification is a commercial technology, further research aims to increase product yields, reduce consumption of catalysts and energy, and lower capital and operation costs. **In IGCC plants with CCS, reducing the energy input to produce oxygen represents an essential research area**.

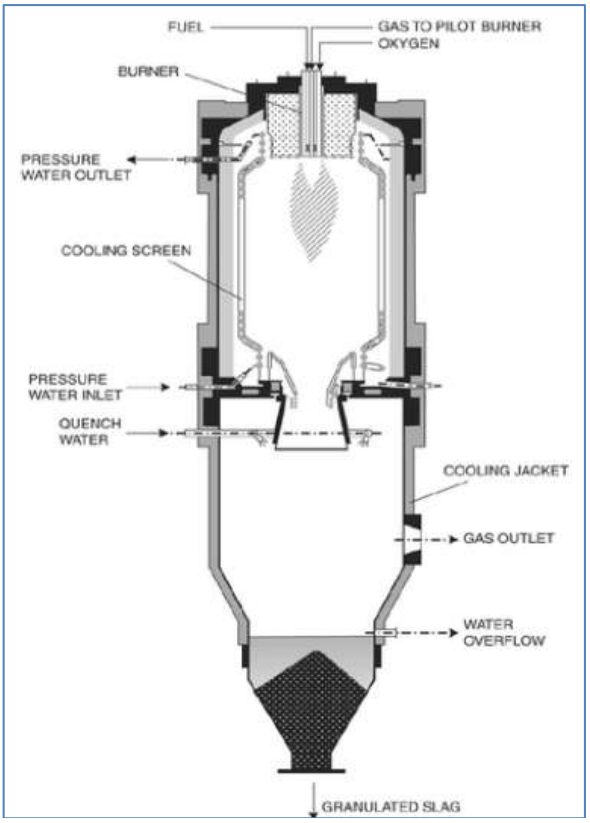

Fig. 17 – Entrained Flow Gasifier

Performance and Cost – Performance and costs of coal gasification plants depend largely on the plant design and the final production objectives. A gasification system that is part of an integrated chemical plant producing methanol, ammonia and electricity differs substantially from a system that only feeds an **IGCC plant** with Carbon Capture and Storage (CCS). **Coal quality is also very important for coal gasification output**. The overnight capital cost of coal gasification plants is given per **GJ of syngas output** and ranges from **$13/GJ** for bituminous coal to **$17.2/GJ** for sub-bituminous coal, as in our case. Similarly, the **syngas production cost decreases** with the increase of coal quality and ranges from $15.6/GJ to $19.3/GJ. The production cost is dominated by the investment cost. However, costs may vary significantly depending on the location. Chinese plants may cost 60-65% of the US and European installations. Syngas may be further upgraded to meet specific demands. Co-production of 20% of H_2 using a H_2 separation unit is only slightly more costly than the basic process, resulting in 5% higher capital and 4% higher product costs. The conversion into synthetic natural gas (SNG), i.e. pipeline quality gas, requires additional processes and costs. If the syngas is converted into SNG, the capital cost increases by approximately 25% and the cost of the final

product increases by 40%, while the conversion efficiency of the process decreases by some 14 percentage points, reaching about 60%.

Table 13: Summary Table: Key Data and Figures for Coal Gasification Technology

Technical Performance		**Typical current international values and ranges**		
System Output (without the production of H_2)		Syngas		
Gasification capacity, output (MWthr)		210-310		
Coal input (GJ/hr)		800-1,200		
Output	**main product (GJ/hr HHV)**	Syngas: 670 – 1,000		
	By-product H_2SO_4 (kg/hr)	120 – 1,350		
Efficiency, thermal (%)		73-75		
Construction time (months)		18-24		
Technical lifetime (yr)		20		
Load factor and availability (%)		90		
Environmental data				
CO_2 emissions (kt/$PJ_{total\ output}$)		55		
CH_4 emissions (kt/$PJ_{total\ output}$)		0.0061		
N_2O emissions (kt/$PJ_{total\ output}$)		0 (only marginal emissions depending on the nitrogen content of the coal)		
Reduction of CO_2 emissions if CCS is applied, %		up to 99%		
Costs (US$)				
Capital cost ($/$GJ_{output}$)		17,2 - 13,5		
Fixed O&M ($/$GJ_{output}$)		1,0 - 0,7		
Variable O&M cost ($/$GJ_{output}$)		1,6 -1,4		
Coal cost ($/$GJ_{input}$)		1,3 - 0,9		
CO_2 capture & compression (US$/t CO_2)		20-80		
Transport & storage of CO_2 (US$/t CO_2)		6-20		
Costs (US$)		**2020**	**2030**	**2050**
Efficiency, thermal (%)		76-78	78-80	80-82
Capital cost, ($/$GJ_{output}$)		16.2-12.5	15.7-12.0	15.2-11.5

Table 14: Performance and Costs of Syngas Production from Different Coal Quality

Performance	**Quantity/yr.**	**Units**	**Enugu State's Sub-bituminous Coal**
Gasification capacity, output		MWt_h	10
Syngas production (HHV)	95,752.421 GJ/yr.	GJ/hr.	10.93
Coal feed	2,567,089.03 GJ/yr.	GJ/hr.	293.05
Net efficiency	78	%	
Costs (US$)			
Total plant cost			
Specific capital cost		US$/GJ	17.20
O&M cost			
Fixed O&M cost		Mill.US$/yr.	5.8
Variable O&M cost, output		US$/GJ	1.6
Coal cost, input		US$/GJ	0.9
CO_2 capture & compression,		US$/t CO_2	78.8
Transport & storage of CO_2		$/t CO_2	18.9
Production cost		US$/GJ	19.3

Potential and Barriers – There is huge potential for coal gasification worldwide, as the technology allows fuel production for many applications such as transport, chemicals, heat and **power production**, as in the case this study. High natural gas prices and limited availability at a regional level are driving factors for investments in coal gasification. Based upon planned projects, the Gasification Technologies Council, a non-profit organization promoting technological advances and surveying the market, expects further significant market growth to reach a global equivalent thermal capacity of cca. **297.8 GWth** or more by 2021. Most of the growth will materialize in Africa and the Middle East (64%), Asia and

Australia (27%), compared with only 9% in Europe and almost no investment in America. Marketable products from new gasification plants include Fischer-Tropsch (F-T) liquids (69%), chemicals (22%) and power (9%). However, because of the need to mitigate GHG emissions and climate change, these market projections appear to be realistic only if **CCS technology is made available**.

By-products. The by-products of coal gas manufacture included **coke**, **coal tar**, **sulfur** and **ammonia**; all useful products. **Dyes**, **medicines**, including **sulfa drugs**, **saccharin** and many **organic compounds** are therefore derived from **coal gas**.

Coke is used as a smokeless fuel and for the manufacture of water gas and producer gas. Coal tar is subjected to fractional distillation to recover various products, including

- **Tar**, for road surfacing;
- **Benzole**, a motor fuel;
- **Creosote**, a wood preservative;
- **Phenol**, used in the manufacture of plastics; and
- **Cresols**, disinfectants;
- **Sulphur** is used in the manufacture of **sulfuric acid**; and
- **Ammonia** is used in the manufacture of fertilisers.

6.2.5 Preliminary Cost of the Main Civil Facilities

The Preliminary Cost of the aforementioned Civil Objects (), including installation foundations of the 3 x Gensets and the Internal Roads, Access Road from the Plant Security Gate to the Free Trade Exit Road,

6.3 MISCELLANEOUS SYSTEM DESCRIPTION

6.3.1 Magnetic separators

Two (2) sets of belt magnetic separators shall be installed in the belt conveying system. These belt magnetic separators will be of self-cleaning, suspended type, and arranged on the head part of the on the Convey Belts CV1, CV2, CV3 and CV4.

6.3.2 Coal sampling system and belt scales

Two (2) sets of Fired Sampling facility and Belt Scales will be installed in the middle of each of the Conveyor Belts. The Convey Belts will also be provided with Sampling System to monitor the coal characteristic and it will be equipped with coal returning device. Electronic Belt Scales will be used with test weight required for accurate calibration.

6.3.3 Syngas cleaning system

Carbon dioxide capture, storage and utilisation unit

Coal is more abundant and cheaper than oil and natural gas, but it exhausts high carbon dioxide gas (CO_2) and sulphur content of the environment load at the time of the use.

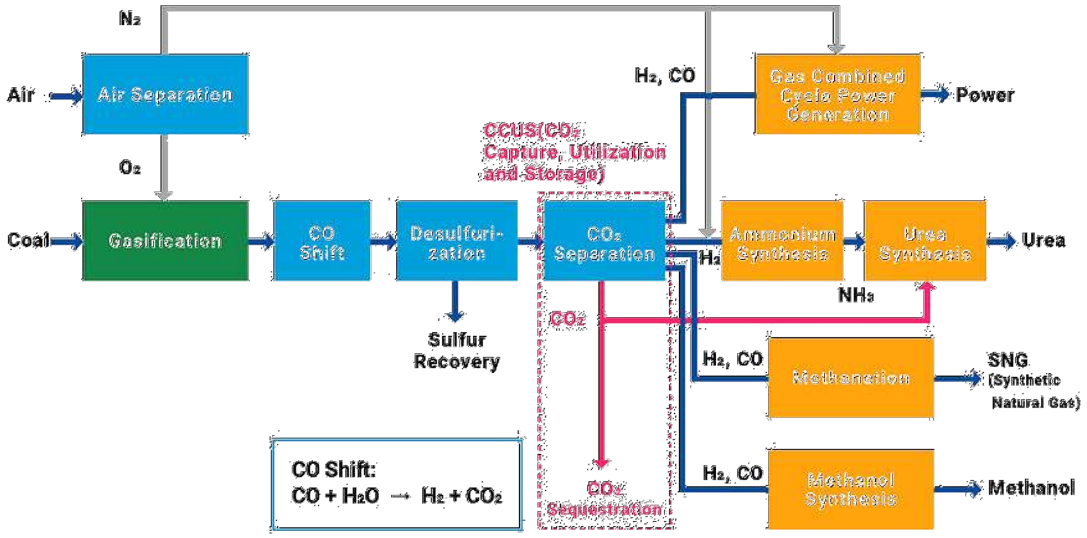

Fig. 18 – CO_2 Capture, Storage and Utilisation Unit

Clean Coal Technology (CCT), which uses coal in high efficiency and clean, is a key technology to reduce the discharge of the material having high environmental load.

Especially since the coal gasification process provides higher energy efficiency in CCT, it is expected to be more widely used for a power generation and chemical raw material production.

Capabilities: Coal Gasification cleaning Technology main characteristics consist of maximizing coal use efficiency and minimizing environmental impact in various plants that use coal gasifier synthetic gases. Some of them are designed to suitably process and produce chemical raw materials from syngas produced by coal gasification.

Sulphur Recovery Unit (SRU)

H_2S removed in the AGR process is sent to the sulphur recovery unit (SRU) as acid gas. SRU recovers H2S as elemental sulphur through the Claus reaction (see the attached figure). Reactions occur in two stages: the flame reaction stage and the catalytic reaction stage. The former consists of a high-performance burner, mixing chamber, and heat removing boiler, while the latter has two to three reactor stages. The sulphur recovery rate of the Claus process is about 95 to 97%. The tail gas that contains unrecovered sulphur is fed to the tail gas treating unit (TGT). The recovered sulphur is stored in the sulphur pit and shipped as product after undergoing a degassing process to remove H_2S. The Claus process is an equilibrium process, and a modified version of it with direct oxidation catalysts stored in the final stage is called subERCLAUS. Since this improved process does not depend on Claus equilibrium, it can attain a 99% recovery ratio without TGT (Licensor: Jacobs Comprimo). It is important for the Claus process that appropriate burners be selected and use the right catalysts to ensure high recovery rate and long service life.

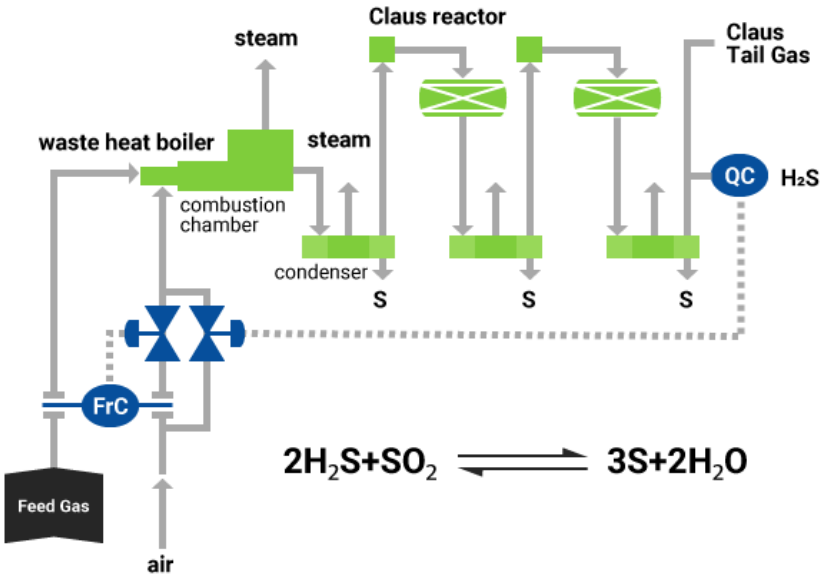

Fig. 19 – Sulphur (H_2S) Recovery Unit

Capabilities: By using TGT process, 99.2% recovery can be achieved.

6.3.4 Environmental considerations

All power plant design, regardless of the type of power plant, must be in accordance with the rules and regulations, which have been established by Federal, state and local governmental bodies.

To meet various environmental regulations, it is often necessary to utilize design features that will greatly increase the cost of the power plant without increasing its efficiency. For example, the cost of the pollution control equipment that will be required for each site under consideration is one such item, which must be carefully evaluated.

6.3.5 Water supply

General requirements

Water supply will be adequate to meet present and future plant requirements. The supply maybe available from a local municipal or privately owned system, or it may be necessary to utilize surface or subsurface sources.

Quality

Water quality and type of treatment required will be compatible with the type of power plant to be built. The quality of water requirement for a sustainable operation of the power plant and its facilities are provided in table 15 below.

Table 15: Technical requirements for the cooling water quality and cooling system

Parameter	Limit Value
WITHOUT EXHAUST HEAT EXCHANGER	
pH value at 25 °C	6.5 to 8.5
Chloride ion content	maximum 100 mg/L
Sulfate ion content	maximum 100 mg/L
Total hardness	3 to 12 °dH
Carbonate hardness proportion of the total hard- ness	minimum 3 °dH
WITH EXHAUST HEAT EXCHANGER	
pH value at 25 °C	6.5 to 8.5
Chloride ion content	maximum 100 mg/L
Sulfate ion content	maximum 100 mg/L
Total hardness	less than 1 °dH
Carbonate hardness proportion of the total hardness	less than 1 °dH
WITH EXHAUST HEAT EXCHANGER – Engine Cooling Circuit	
pH value at 25 °C	6.5 to 8.5
Chloride ion content	maximum 20 mg/L
Filling Volumes	maximum 2 m^3
Temperature at exhaust heat exchanger outlet	maximum 110 °C
COOLING WATER / COOLANT FOR THE COOLING CIRCUIT	
pH value at 25 °C	9 to 10.5
Electrical conductivity	less than 0.1 mS/cm
Oxygen (O_2)	less than 0.05 mg/L
Chloride	less than 20 mg/L
Copper (Cu)	less than 0.05 mg/L
Total iron (Fe)	less than 0.05 mg/L
Earth alkalis	5 to 10 mg/L
Total hardness	less than 0.02 mmol/L

Water rights

If water rights are required, it will be necessary to assure an agreement for permanent water rights for the supply of sufficient quantity for present and future use. But, based on our experiences, there is a huge water supply problem within the whole Nigeria. So it absolutely not possible to secure a sustainable and satisfactory supply of quantity of water required by the power plant.

Water wells

If the makeup to the closed system is from water wells, a study to determine water table information and well drawdown will be required. If this information is not available, test well studies must be made. This proposal is not possible due to environmental concerns. Besides, the underground water is protected and reserved only for human consumption because as stated earlier, it is one of the cleanest waters in the world that can be directly consumed without additional treatment.

NOTE:
The only available possibility is to pipe raw water from Oji River and treat it in accordance with the requirement of the technologies and equipment of the plant and in table 15 above.

6.3.6 Fuel supply

Site selection will take into consideration fuel storage and the ingress and egress of fuel delivery equipment.

CHAPTER III: ENVIRONMENTAL CONSIDERATIONS

1. INTRODUCTION

The environmental benefits associated with the implementation of the 10 MWh IGCC power plant can easily be estimated by determining the reduction in the production of air pollutants associated with the plant.

It is our belief that this project represents an excellent solution for meeting Nigeria's looming energy challenge with sustainable environment development and protection.

To reiterate some of the points we made earlier, the facility will burn clean syngas as provided in **Figures 7 and 14** from a processed coal and cleaned from substances and contaminants, using Clean Coal Technology (CCT), which uses coal in high efficiency and clean, is a key technology to reduce the discharge of the material having high environmental load (e.g. Gasifier and Genset Combustion emission – CO_2 and SO_x) below limits. Besides, the installation of the CO_2 Capture, Storage and Utilisation Unit (CCSUU) and the Sulphur Recovery Unit (SRU) brings the IGCC to zero air emission. The traditional method for controlling SO_x emissions is dispersion via a tall stack to limit ground level emissions. The more stringent SO_x emissions requirements in force today demand the use of reduction methods as well, which include the use of low sulphur fuel, desulfurizing fuel and CO_2 Capture.

The Plant is designed to produce minimal noise; and will take up significantly less square footage. It will also be highly efficient with an efficiency rate compared to simple-cycle plants, which typically have efficiency rate. The higher efficiency means that it will have lower fuel costs and lower emissions per unit of energy produced than simple-cycle alternatives. Another important advantage is location. Medium and low voltage distribution lines and access roads for the delivery of coal run around the site; and the nearest home is about **200 m away**. The facility is also close to the major demand centres of Enugu State and Enugu Electricity Distribution Zone, which enable the export of extra generated power more efficiently and avoid the energy loss that occurs during long-distance distribution.

This IGCC Project will also be able to export steam and hot or chilled water through co-generation whenever a buyer for the heat (steam or hot water) becomes available.

A final advantage is the XENERGI's long-term flexibility to adapt to its surroundings. The facility and site will be maintained and landscaped to be consistent with the XENERGI's vision to develop Enugu State.

2. COMMUNITY CONSULTATION & ENVIRONMENTAL ASSESSMENT

One of the biggest things the Project Company (XENERGI LTD) has been going for it is that all the necessary environmental approvals have been obtained for the project to move forward for the construction of the 10 MWh IGCC.

Starting in May 2013, a formal consultation process was launched to inform all relevant stakeholders about the proposed facility and solicit their input.

From the very start, we made this process as open, transparent and as accessible as possible.

Before the consultation process even began, Engr. Emeka Ene and Company Top Management met with various stakeholder groups to identify and understand their perspectives on the 10 MWh IGCC project in the Free Trade Zone. This helped them significantly in developing a consultation process relevant to the communities' needs and concerns.

The open houses introduced participants to the Project, the Environmental Impact Assessment (EIA) process and the community's consultation process. They also enabled us to get feedback from the communities, at an early stage in the process, on local environmental considerations and other issues or concerns that should be addressed. Local Community's members were informed of the open houses through invitation, advertising in local newspapers, and on the MDACI's website.

In addition, we met locally with a number of community groups, including the Project Environmental Liaison Committee.

We believe that they also met many times with various government agencies in Enugu the capital of Enugu State and Federal level for instance the Federal Ministry of Power and Federal Ministry of Commerce. These included the Ministry of Environment and the Bureau of Land and Survey of Enugu State.

The Ministry of Environment of Enugu State confirmed in **March 2012** that the project could proceed. This represents a major advantage of the **10 MWh IGCC Project** over other energy options suggested for the area.

To reiterate, we've been very open and above-board about this project since day one.

We will continue to take this approach. We will meet with stakeholders on an ongoing basis to get the input and inform them of developments throughout the course of the project.

By the way, up until this year no one suggested that building the plant in the Free Trade Zone, 9th Mile Corner, Enugu, Enugu State would make opposition to the plant go away.

3. COMMUNITY CONSIDERATIONS

We have taken a number of steps to ensure positive outcomes for the local communities as well. These include:

- Constructing the plant to ensure that noise under normal operating conditions does not at specific locations exceed **45dBA** – which is equivalent to the sound of rustling leaves;

- Installing Continuous Emissions Monitoring systems and reporting results annually to the Ministry of Environment of Enugu State; and

- Continuing with providing information to the public and creating a volunteer Community Liaison Committee.

We will continue to be in regular discussions with the community regarding the project and have a full-time person dedicated to community liaison.

4. PUBLIC SUPPORT

Finally, we would like to say a few words about public support. According to a recent survey conducted in May, close to three out of every four Inhabitants of 9th Mile Corner and its neighbourhood – about **73.5%** – support the idea of a coal-to-power generation.

In addition, various business groups have told us that it's important to move quickly to resole Nigeria's energy issues. These include the Nigerian Energy Commission (NERC), the Board of PHCN, and the Enugu State government is also supportive of the Project.

5. EMISSION LIMITS

5.1 COAL POWER PLANT PROJECT EMISSION LIMITS

NO_x emissions < 25 mg/Nm^3 at 15% O_2, dry.

CO emissions < 100 mg/Nm^3 at 15% O_2, dry.

5.2 NATIONAL EMISSION LIMITS

There are no emission limits, especially applicable to Coal Power Plant in Nigeria. The general limits are given in some cases and the choice of applicable limits is based on socioeconomic and political conditions. (Ref: Guidelines and Standards for Environmental Pollution Control in Nigeria, Federal Environmental Protection Agency (FEPA) 1991). Those of potential interest to XENERGI's CPP Project are:

- Carbone dioxide (CO_2) from stationary sources 10% by volume; and

- Oxide of Nitrogen (NO_x) from stationary sources: 359 ÷ 1,000 mg/m^3.

The site CO_2 emissions are expected to be lower than 0-0.1% by volume and NO_2 emissions are expected to be lower than 50mg/Nm^3 (Nm^3 is a normal cubic meter of a dry sample of as normalized to 15% of O_2 at 279K and 1atm).

5.3 EMISSION LIMITS COMPARISON – EU/Nigeria/World Bank

The XENERGI's CPP emission is regulated by the European Union Large Combustion Plant Directive (2000/80/EC), which is based as a source for emission limits for thermal power plant with an input of energy greater than 50MWt. The Directive gives the following

emission limits for steam turbine at reference conditions of 15% of O_2 at 278K and 1atm for steam turbine load above 70%.

The Coal Power Plant emission regulated by the European Union Directive 2001/80/EC emissions limits (50mg/Nm^3 of NO_2) is under the mission limits of the World Bank Group Pollution Prevention and Abatement Handbook (125mg/Nm^3 of NO_2) and the emission limits provided by the Nigeria Air Quality Standard (85mg/Nm^3 of NO_2).

The 10MWh IGCC, is designed for zero emission and wastes. All the residues from the power plant are collected, treated, packaged and sold in the international market as commodities.

5.4 AIR QUALITY

Our analysis shows that the proposed 10MWh IGCC emissions of air pollutants (nitrogen oxide (NO_x), sulphur dioxide (SO_2) and Carbon monoxide (CO) will not violate ambient air quality standards and the air quality impacts from these emissions of the Project are insignificant. The project's air quality impacts from directly emitted particulate matter (PM) and of the ozone precursor emissions of NO_x, volatile organic compounds (VOC), and PM precursors of NO_x and SO_2 shall be could be reduced and monitored by using Best Available Control Technology, and will provide emission offsets for their NO_x, VOC, and PM emissions. These mitigation measures reduce the potential for impacts (including cumulative impacts) from directly emitted PM10, as well as ozone and secondary PM formation to a level of insignificance.

5.5 MATERIAL AND ENVIRONMENTAL COMPATIBILITY

Materials issues are at the heart of any mechanical design, and in the case of IGCC, should be considered with respect to the environment, and lifetimes of the IGCC components. These issues should not be complicated because the IGCC components will be installed in the same location with similar conditions. Principal concerns are associated with corrosion, in hot, humid and salt air climates.

6. LEGAL AND REGULATORY FRAMEWORKS

The Federal Ministry of Environmental (FMENV) is the major Environmental Regulatory Agency for the implementation of Power and Energy Projects in Nigeria. There are also provisions for environmental issues to be regulated by Federal Acts and Decrees, States' Edicts and Governments' Edicts as well as international convention ratified by the Federal and State Governments.

This project is to be carried out in compliance with the XENERGI's environmental policies and the local, national and international statues applicable to the Power Generation facilities and environment in Nigeria. These are as follows:

- The defunct Federal Environmental Protection Agency (FEPA) now Federal Ministry of Environment (FMENV) regulations, guidelines and standards concerning car repairs and maintenance workshops or car manufacturing companies in Nigeria;

- The NERC regulations, guidelines and standards;
- All International Conventions on Environmental Protection that are ratified by Nigeria;
- The environmental and operational policies of the XENERGI LTD.

6.1 FEDERAL REGULATIONS

The FEPA, which has now transformed into the FMENV, was established in 1998 by the Federal Government of Nigeria to protect, restore and preserve the Nigerian ecosystem (Decree No. 58 of 30th December 1988). In 1992, the EIA Decree No. 86 was enacted by FEPA, which became known as the National Environmental Impact Assessment Decree No. 86 of 1992. The decree made EIA mandatory to all major public and private projects in Nigeria and is set out to achieve the following:

- Consideration of the likely impacts and the extent of these impacts on the environment before embarking upon any project or activity. Promotion and implementation of appropriate policy in all Federal lands, consistent with all laws and decision-making processes through which the objectives of the Decree may be achieved. Development of procedure for information exchange, notification and consultation between organizations and persons where the proposed activities are likely to have significant environmental impacts. This Decree gives specific powers to FMENV (FEPA) to facilitate environmental assessment of projects. The *EIA Procedural Guidelines* including car repairs and maintenance workshops or car manufacturing companies Projects and *EIA Sectorial Guidelines* published by FEPA in 1995 is intended to assist in the proper and detail execution of EIA for car repairs and maintenance workshops or car manufacturing companies projects in consonance with the EIA Decree No. 86 of 1992 Fig. 4-1 below is a flow chart which outlines the FEPA EIA management procedures.

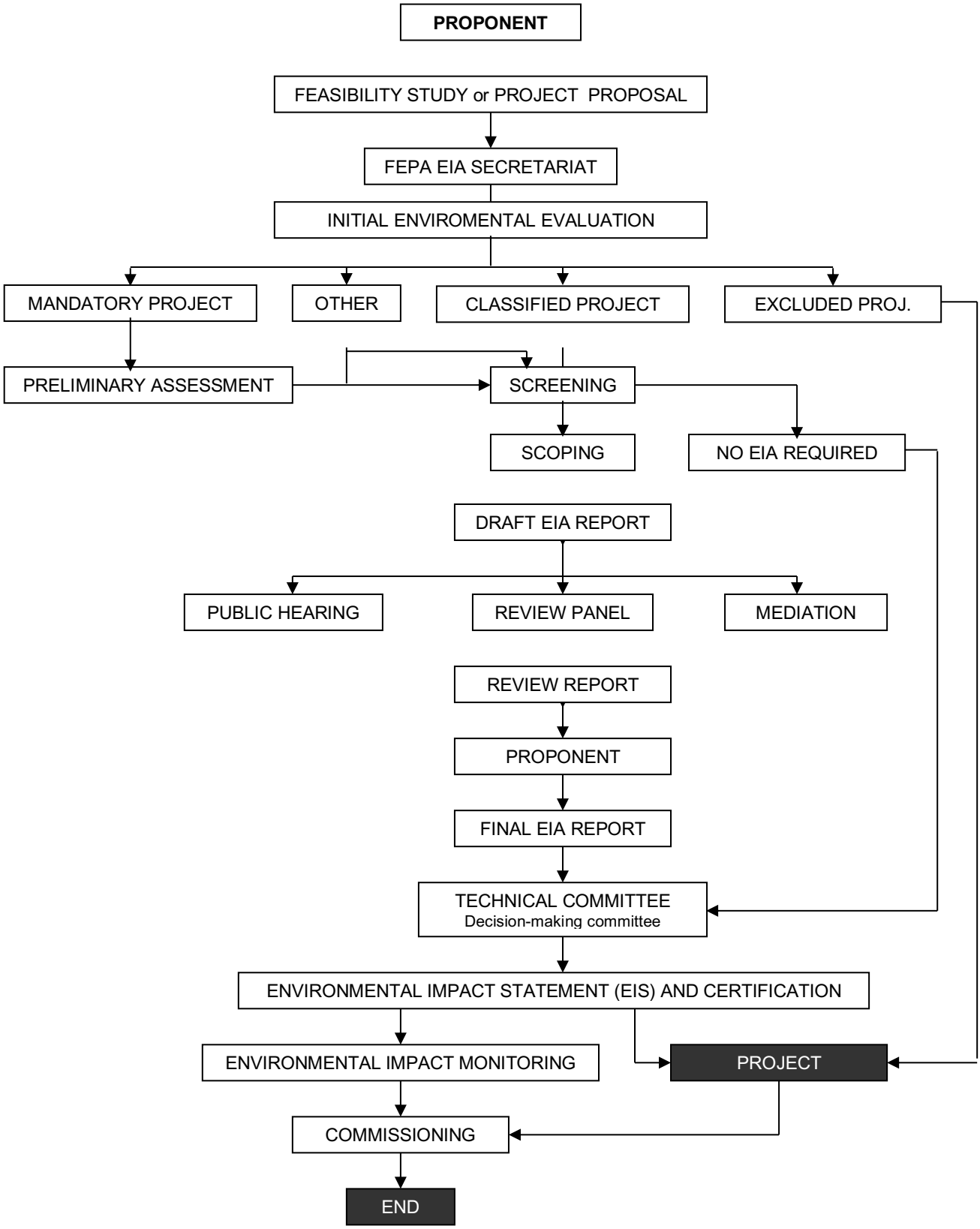

Fig. 20 – EIA Flowchart Review Management Procedure (FEPA EIA Procedural Guidelines, 1992)

The National Guidelines for *Environmental Auditing Nigeria (1999)* makes provision for the post-commissioning monitoring of environmental performance of a projector or facility.

This is otherwise known as *Compliance Auditing* under this provision, it is mandatory for all the industries concerned to conduct Environmental Audit (EA) every three years, or whenever it is so demanded by the Executive of FEPA/FMENV.

The stage of EA is shown at the bottom of the flow chart in Fig. 4-1 above.

Other Federal legislations concerned with environmental planning and provision of environmental limitation and standards, which are relevant to proposed project include:

- National Environmental Protection (Effluent Limitations) Regulation (S. 1.8) 1991;
- National Environmental Protection (Abatement Industries and Facility Generating Waste Regulations (S. 1.9) 1991;
- National Environmental Protection (Management of Solid and Hazardous Wastes) (5.5.1) 1991;
- Guidelines and Standards of Environmental pollution control in Nigeria (1991);
- National Guidelines and Standards for Waste Management in Oil and gas Industries of 1992;
- Harmful wastes (Criminal Provisions) Decree No. 42 of 1988;
- Oil Pipeline Ordinance (Cap) 145, 1956 as amended by the Oil Pipeline Act, 1965.

  The Oil pipeline Act, 1965 does not relate directly with Environmental Protection but is relevant to this XENERGI's CPP because, the oil waste from Power Plant is to be piped down to the sewage facility. Oil Pipeline Ordinance (Cap) 145, 1956 as amended by Oil Pipelines Act, 1965 authorizes the Minister of Petroleum to issue Permit to Survey (PTS) the pipeline route for the purpose of transporting mineral oil, or any such products to the desired destination for the purpose connected with the company's environmental management policy. Section 15(1) of the Oil Pipeline Ordinance has provided guidelines to the management on issues related to socio-economic/cultural impacts of industrial development.

  It prohibits the entry, possession or use of any of the following land unless consent of the persons in-charge or occupiers have been obtained.

  (i) Any land used as burial ground or cemetery;

  (ii) Any land containing grave, grotto, and trees or things held to be sacred or the object of veneration;

  (iii) Any land under actual cultivation.

The National Environmental regulatory framework provides numeric limits and standards for ambient environmental quality and for emissions and effluents. The limits and

standards that are relevant to this XENERGI's CPP activities are presented in tables 16 to 18.

Table 16: Noise Exposure Limits for Nigeria

Duration (hrs./day)	Permissible Exposure Limits dB(A)
9.0	90
6.0	92
4.0	95
3.0	97
2.0	100
1.5	102
1.0	105
0.5	110
0.25 or less	115

Source: FEPA, (1991)

NOTE
Exposure to impulsive or impact noise should not exceed 140 dB(A) peak sound pressure level.

Table 17: Nigerian Ambient Air Quality Standard

Pollutants	Time of Average	Limit
Particulates	Daily average of hourly values 1 hour.	250µg/m^3 *600µg/m^3
Sulphur oxides (sulphur dioxides)	Daily average of hourly values 1 hour.	0.01ppm (26µg/m^3) 0.10ppm (260µg/m^3)
Non-methane Hydrocarbon	Daily average of 3-hourly values.	160µg/m^3
Carbon monoxide	Daily average of hourly values 8-hourly average.	10ppm (11.4µg/m^3) 20ppm (22.8µg/m^3)
Nitrogen oxides (Nitrogen dioxide)	Daily average of hourly values range.	0.04ppm-0.06ppm (75.0µg/m^3,113µg/m^3)
Petrochemical Oxidant	Hourly values	0.06ppm

Source: National guidelines and standard for industrial effluent (FEPA, 1991).

NOTE
Concentration not to be exceeded for more than once a year.

Table 18: Effluent Limitation Guidelines in Nigeria for all categories of industries. (mg/1)

Parameter	Limit for discharge in to surface water	Limit for land application
Colour (Lovibond Units)	7	-
pH	6-9	6-9
BODs at 20°C	50	500

6.1.1 National Inland Waterway Authority Decree No. 13, 1997

The Decree created the National inland waterways Authority. It is concerned with regulation of the activities in the inland waterways within the territorial boundaries of Nigeria. It undertakes capital and maintenance dredging and hydrological and hydrographic surveys. Although its spheres of operation borders on improvement and development of inland waterways to make them suitable for navigation it would appear that an ancillary duty is imposed upon it not to endanger the aquatic habitat in the course of its operations.

6.1.2 Environmental sanitation and protection task force

The Edict created the Environmental Sanitation and Protection Task Force – (CRS) Edict No. 6, 1984. Apart from ensuring the general effective cleanliness of the state, it is also empowered to lead the protection of the environment from erosion, flood, contamination and pollution.

In essence, it is clothed with the responsibility of protecting and preserving the environment. In the process nothing precludes it from enforcing the federal environmental laws already mention within the state.

6.1.3 Quarries Act Cap 385 Laws of the Federation of Nigeria, 1990

The act provides for and regulates quarrying activities in Nigeria. It prohibits unauthorized quarrying the activities for industrial use and diversion of watercourse or impounding of water for that purpose. The Act gives the Minister for Mines and Power the power to make regulations for prevention of pollution of natural water supply.

6.1.4 Criminal Code Cap 42 Laws of the Federation of Nigeria

To further complement respective environmental laws, the Criminal Code by section 247 makes it an offence to violate the atmosphere in any place so as to make it noxious to health of persons or to carry on any business in the neighbourhood or to do any act which is likely to spread the infection of a disease dangerous to human being or animals. The purport of this legislation is to secure a conductive environment suitable for human being and animals generally.

6.1.5 Other guidelines

- The Convention on the Prevention of Marine Pollution by Dumping of Waste, 1972;
- Montreal Protocol on Substances that Deplete the Ozone Layer, 1987; and
- The Basal Convention on the Control of Trans-boundary Movement of Hazardous Waste and New Disposal, 1989.

The Convention on Biological Diversity, 1992.

All industrial activities that will result in the biological, chemical, physical, cultural and social alteration or modification of the natural environment must be made a subject of EIA. In the process, the otherwise unforeseen and unidentified impacts of the proposed project are curtailed and made to comply with minimum standards through the legal framework.

Through follow-up program, accuracy of EIA of projects is verified and the effectiveness of measures taken to check the adverse environmental effects are ascertained.

In conclusion, for all purposes and intent, the Environmental Impact Assessment Decree No. 86, 1992 anticipated EIA of projects or activities prior to their establishments. The

case at hands does not fall squarely within the ambit of the Decree given the circumstances surrounding the CPP Project.

6.1.6 International Regulations

The relevant international regulatory guidelines to which Nigeria has adopted are contained in the World Bank Operational Directive 4.01 „Environmental Assessment“ 1991 in which projects are classified according to the nature and extent of their environmental impacts. It supports the use as a vital tool for achieving sustainable development.

7. CONCLUSION

In talking to our neighbours in Enugu State, we learned people are interested in how XENERGI LTD is working to improve its environmental performance as a Company, and especially how the proposed 10MWh IGCC would work to minimize environmental impacts. MDACI/MDACI Consortium lays emphasis on the balance of energy needs and environmental interests. The selection of the most efficient EU technologies and equipment turbine will minimize air emissions and ensure the best possible air quality, well within compliance with air quality standards. Also, recent improvements in control technology allow for reduced emissions.

The proposed 10MWh IGCC will meet all health-based air emission permit requirements. In fact, it is designed to be one of the cleanest power generating units in Nigeria and in the world. Today, it is said that IGCC are the energy of the Future.

CHAPTER IV: THE PROJECT ECONOMY AND BUSINESS PLAN

1. INTRODUCTION

This economical part of the report will review the project from the following points of view, demonstrating its net economic benefits are sustained during the project's economic life, including its financial and institutional sustainability (*i.e.* the financial evaluation of the project and financial analysis of the project-executing and/or implementing entity, XENERGI LTD and its consortium). For this purpose, we will need to lay emphasis on:

a) determining the total project cost;
b) projecting the overhead and running cost;
c) assessing project results – Gross and Net Profits;
d) projecting future cash flow and profitability of the Project; and
e) assessing the financing plan for the Project.

This report is based on data and information provided by NERC, and MDACI/MDACI Consortium and from estimates and market survey carried out by the project consultant. Based on previous experience, the consultant's assumptions are reasonably used to translate the aforementioned information into conventional accountant format comprising:

a) Estimates of project cost;
b) Projected profits and loss statement for fifteen (15) years of operations management;
c) Projected cash flow for fifteen (15) years of operations management; and
d) Project balance sheet for fifteen (15) years of operations management;

2. PREDICTABLE SAMPLE TO BE USED IN THIS REPORT

The O&M and capital additions data to be used in the complete study shall be consisted of annual observations over the period from **2023 through 2038** for commercial power plant. Several other variables will be available during the first two (2) years only, starting from **2023**.

If there will be substantial regional variations in the levels of labour and materials costs, then they can increase at roughly the same rate. As a result, there will be much less regional variation in the changes in these costs over time. This point is important, because the statistical analysis will focus on changes in costs over time.

3. SCHEDULE AND RISKS

3.1 Project Schedule

The Proposed schedule of work for the XENERGI's 10 MWh IGCC Power Plant Project may be summarized into Three (3) major phases, viz:

a) Development phase;
b) Engineering, Procurement and Construction (EPC) Phase; and

c) Commercial Operation phase.

The longest phase is the EPC, which is scheduled for a period of 12÷18 months

3.2 Risk and Risk Mitigation

Some of the significant risks that could adversely affect the Project and its promoters include fiscal-risk, country risk, performance risk, and personnel risk. While all these risks represent difficulties that must be overcome, mitigation of the risk elements through cooperation between the project promoters and the Federal Government of Nigeria can result in the successful completion on the XENERGI's 10.2 MWh IGCC Project.

3.2.1 Fiscal and Country Risks

The primary fiscal risk and country risks facing the Project include:

- International currency availability and convertibility;
- Local inflation and fluctuation exchange rates;
- Project finances already taken care of; and
- Uncertain rate of return from project promoters.

Mitigation of each of this risk has been considered in the feasibility study for example, the PPA or guaranteed market shall ensure that the project receives a reliable revenue stream of convertible currency in other to:

- pay for certain variable operating and maintenance (O&M) costs, the largest of which is usually fuel;
- pay for certain fixed O&M costs;
- recover the investment of the project;
- make debt services payment; and
- earn a reasonable return over the life of the project.

In order to facilitate the convertibility of local currency to foreign currency, the Federal Ministry of Finance in Nigeria will be required to register the Project.

3.2.2 Performance Risk

Performance risk will be mitigated by obtaining completion guarantee from the ISTROENERGO INTERNATIONAL, A.S. (IEI) that is responsible for the complete construction and operation of the power plant.

3.2.3 Personnel and Material Risks

Nigeria (especially Lagos and the Niger Delta area of Port Harcourt and Warri) faces high rates of crime, including armed robberies of work compound and shops, car hijacks, highway robbery, break-ins and muggings. Oil Companies doing business in the Niger Delta faces sometimes violent opposition from local communities. These aforementioned personnel and material risks do not affect this State.

These types of personnel and material risks can be mitigated by having in place comprehensive security measures that ensures the safety of both personnel and equipment. MDACI Consortium is well experienced in provision of necessary security measures and maintenance of good community relations to minimize the effect of such risks during the construction and operation of the Power Plant.

4. INSURANCE

Insurance represents the estimates for annual premium payable for to cover assets. We allowed an insurance premium of the Project during operation to be fixed at 1% maximum of the total project cost by a reputable insurance company registered in Nigeria.

5. TAXATION

The annual taxation on profits to be paid to the Federal Government of Nigeria – FGN – is estimated at cca. 34% maximum of the Net profits. Pursuant to the FGN's energy policy to motivated investors, a tax holidays for a period of 3-5 years of operation is approved to all Independent Power Producer – IPP – project by the Federal Government of Nigeria and the Nigerian Investment Promotion Commission (NIPC).

6. ESTIMATES OF PROJECT COSTS

6.1 TOTAL INVESTMENT CAPITAL

Based on the US Energy Information Administration (EIA), which forms the basis for the calculation of **2021-2022** Annual Energy Outlook, the Total Investment Capital for the 10MWh IGSC power plant, including the Six (6) first months of operations management is **€17,3 Million**. Of course, this cost also includes civil object, materials and labour costs. This cost does not include the electricity distribution and connection costs of the customers to XENERGI's electric power networks. The technology cost required for the generation of 10MWh is cca. **€15.70 / kW**.

This study has shown that the **XENERGI's 10 MWh IGSC Project Capital Cost** (**€1,843/kW**), which includes the plant's Civil Objects and Operations Management Costs is cheaper than the IGSC Power Plant Capital Cost provided by the US Energy Information Administration (EIA) International for the global market.

The Total investment Capital required for the implementation of **13,500 MWh IGCC** power plant is **€22,52 Million** and the Capital Cost is. **€2,407 kW**.

NOTE:
Though the fuel source is clean, cheap and renewable, most renewable power plant technologies utilizing this kind of fuel are the most expensive as compared to plant using fossil fuels. Among renewable energy technologies, wind power plant is the less expensive. Aside from capital extensiveness, low-capacity factor (except geothermal) makes the cost of energy produced from renewable energy even higher.

7. OPERATION AND MAINTENANCE COSTS OF THE PROJECT

For an efficient operation of the Project, it is projected for the Plant to employ one (1) Manager Director (MBA graduates/Economics) in the field of Energy and Economy. The

Chairman and Managing Director shall lead, organize, manage and control the aforementioned power plant as one team.

The estimated number of employees required for the operation of the 10 MWh IGCC power plant is **31 persons**, including the Managing Director, the Financial Director and the Technical Director.
The wages policy and conditions of employment used in this report are based on the following criteria:

a) Other employees, excluding Chairman and Managing Director and Managers, shall at least have a bachelor's degree or graduate of secondary school with a minimum experience of five (5) years.

b) An average salary of US$709.53 (€567,60) per month shall be payable due to regular extra hours and on the scheduled shifts (day and nights shifts). There shall be only day shift.

c) Adoption of most of the conditions of services and payment of fringe benefits obtainable in similar organization.

The **10.2 MWh IGCC** power plant systems can be very heavily automated, which minimizes the amount of staffing that would be needed to operate it sustainably. How the plant is owned/operated has a big impact on staffing and other operational requirements. Some options are:

- Utility owned facility;
- Community or cooperative owned facility; and
- Independent business owned facility.

The power plant will depend on staffing for other functions that any of the above entities currently have at or near the facility. If this is an independent facility with no other linkage, the staffing costs will be much higher as opposed to a shared workforce. This is because many of the functions of the staff at the power plant will involve checking gauges and meters to make sure the system is functioning within acceptable parameters.

Depending upon individual state regulations/requirements, a Coal Power Plant may or may not require a licensed steam engineer on site during all hours of operation. It is recommended that in lieu of a licensed engineer, at least one watch person be assigned to the plant each shift to oversee the operation.

In all likelihood, a plant will have to have two to three individuals on site during all hours of operation. A power generation engineer or watch person plus staff needed for gas fuel control would be a minimum requirement.

7.1 PERSONAL REQUIREMENTS, FUNCTIONS AND COSTS

7.1.1 Top Management and Functions

THE MANAGING DIRECTOR[14]

Job Description

The role of the Managing Director (MD) is to look after the interest of the Project by ensuring that the Project functions for sustainable operation are commercially sound for the principles and objectives it is built for. He would be ably supported by **Three (3) full time Functional Directors** as provided below.

The role of MD could be summarized as follows:

a) Create strategic vision for the business that stems from Project's strength and builds on its competitive advantages.

b) Create and work with the Management that is capable of helping and supporting him in the overall direction and governance of the Project.

c) Establish basic priorities, ethical values, policies and attitudes that will transform the company from being a repeating culture into a learning culture; in still a sense of personal involvement and commitment to the strategic vision throughout the Project.

d) Act as Managing Director with a clear mandate to achieve expected/laid down standards of operational, financial and administrative performance of the Project.

e) With the help of concerned whole time Directors, he is to maintain standards of performance in terms of criteria such as customer services, product quality, technological leadership, market share and financial measures that will meet expectations of the investors, the Consumers and all other stake holders.

f) Maintain public relations with all stakeholders, especially at the Government level.

g) Lead the Project so as to transform it into a platform for serving the consumers and attract other investments.

h) Chair the General Meetings. The overall responsibility of Managing Director is to effectively manage the Project in totality and ascertain continuous and sustained growth with improved performance enabling the Project to increase consumer satisfaction and commercial viability.

Eligibility

In line with the demands of reforms, the eligibility criteria for MD is suggested as follows:

[14] The CMD shall be appointed by Project Operations Management Company, POLYMONT France.

a) Person with a bachelor or master's degree.

b) Continuous professional experience in administration and adequate exposure of working at the level of Chief General Manager or higher in the power sector.

c) The total professional experience should be at least continuous 25 years in Administration/Engineering/Finance and/or Accounts.

d) Preferably he/she has attained minimum age of 30 years on the date of selection. Person should be physically and mentally fit to hold such responsibility and should have vigilance clearance at the time of appointment.

DIECTOR OF FINANCE AND ACCOUNTS

Job Description

The role of the Chief Financial Executive (CFE) is to manage the financial business in totality and ascertain a continuous growth with improved performance enabling the Project to increase profitability. He should interact with the Management and take directives from the **Managing Director** in order to uphold the interest of the stakeholders and maintain transparency. He will be a whole time Director of the Project.

To be specific, the following responsibilities and tasks are to be discharged by the Director of Finance and Accounts:

a) Development of business strategies and operating plans that reflect the long- term corporate goals and priorities established by the corporation.

b) Maintain dialogue with MD and Management to ensure that the goals and priorities are updated to reflect changes in the external environment.

c) Restructuring the business portfolio in line with **Management**'s decision that determines the future shape of the Project.

d) He will be responsible for resource planning, financial budget preparation, loan servicing plan and implementation. Auditing of annual accounts after compilation of accounts.

e) He will also be responsible for monitoring of financial operations.

f) He will look into the financial aspects of procurement activities.

g) He will be responsible for proper planning and fund management for optimum use of funds and will ensure timely availability of funds.

h) He is totally responsible for all kinds of financial and banking affairs and budget preparation.

i) Finalization of annual budget, resource management and loan servicing.

j) He is to monitor budget preparation works by sub-ordinate officers and final budget to be scrutinized by him.

k) He is to be in liaison with the Project Company, XENERGI LIMITED, the electric power purchaser, the receiving bank (herein also known as the guarantor of the Bank) and the other appropriate agencies for all financial dealings of the Project.

Eligibility

a) A graduate with a minimum of five (5) years of experience in Finance and Accounts. Preferably a Chartered or Cost Accountant, or MBA (Finance).
b) Should have experience of at least 5 years in the Power Sector and worked as Chief General Manager or equivalent in Finance and/or Accounts.

c) Preferably he/she has attained minimum age of 30 years on the date of selection Person should be physically and mentally fit to hold such responsibility and should have vigilance clearance at the time of appointment.

TECHNICAL DIRECTOR

Job Description

The role of the Technical Director is to manage the technical aspects of the Project in totality and ensure continuous operation and growth with improved performance enabling the Project to meet its objectives following sound operational and commercial principles. He will be a whole time Director and is to be responsible for all major decisions related to technical matters.

The following responsibilities are proposed to be entrusted to the Technical Director.

a) He is to interact with different functional heads within his jurisdiction to communicate and control, monitor inspects performance of operation and maintenance work on generation, transmission and distribution including revenue collection and commercial matters. He will also handle and advise all technical matters of the corporation related to planning, design, technical specification, project report, plant and machinery maintenance, T&D project execution, tariff, maters, power generation, quality control, etc.

b) Billing, Metering and Revenue collection will be one of his prime responsibilities, along with quality power supply to consumers.

c) He is to interact and communicate all technical decision on detailed discussion with other Directors. He is also to prepare agenda note on technical proposal for placing it in the Board for approval.

d) He is also responsible for interaction in technical matter with person/ organization/institution outside the corporate boundary and to build public awareness programme on technical activity of the corporation. He is to discuss and

communicate technical decision to concerned counterpart or authority on behalf the corporation.

e) Organize MIS to fulfil the requirements of Nigerian Electricity Regulatory Commission (NERC).

All activities of the Project will be influenced by the technical decision of the Technical Director.

Eligibility:

a) Person with a bachelor's degree in the branch of Electrical Engineering from a recognized institute/University.

b) Must have served continuously for five (5) years in the Power Sector and worked as Chief General Manager or equivalent.

c) He must have adequate knowledge in planning, designing, operation including commercial activity, maintenance of power plant, lines, transmission and distribution substation, technical evaluation of tenders etc. Preferably he/she has attained minimum age of 45 years on the date of selection.

d) Person should be physically and mentally fit to hold such responsibility and should have vigilance clearance at the time of appointment.

DIRECTOR OF CORPORATE AFFAIRS

Job Description

The role of the Director of Corporate Affairs is to run, co-ordinate all matters related to running of administrative machinery of the Project. He will be a whole time Director of the Project. The following responsibilities are proposed to be entrusted to the Director of Corporate Affairs.

a) To develop business strategies of the Project for achievement of goals of the Corporation and prioritize the same (Corporate Plans etc.).

b) For discharging his responsibilities, he would coordinate with different wings of the Project.

c) As he is looking after major portion of administrative function of the Project, maintenance of organizational discipline is his responsibility.

d) He is to interact with the Project MD for decisions regarding implementation of administrative activities.

e) Human resource management.

f) He is also responsible for controlling, dealing legal matters, transfer, posting, recruitments, Trainings, etc.

g) Security of the assets and other aspects as may be required from time to time.

h) All press release, public relations, land and property matters are also to be handled by his Directorate.

i) He is also to maintain liaison with State and Federal Governments, local bodies, other organizations for running day-to-day affairs of the Project.

Eligibility:

a) A graduate preferably with MBA or a postgraduate degree in industrial relations or HR or a Company Secretary.

b) Must have served continuously for 5 years and worked as Chief General Manager (Administration) or equivalent.

c) Preferably he/she should attain minimum age of 45 years on the date of selection. Person should be physically and mentally fit to hold such responsibility and should have vigilance clearance at the time of appointment.

7.1.2 Operations Management and Functions

GENERAL MANAGER GENERATION (GRADE E-9)

Responsibility

a) He is to prepare generation schedule, budget for O&M and new generation scheme, checking of Detailed Project Report (DPR) for new scheme, specification and purchase document scrutinizing, inspecting and monitoring of generation project O&M works.

b) He is the Technical guidance to subordinate officers or GMS, arrangement of inventory flow for works, optimum use of time for breakdown maintenance, erection process etc.

c) He has the overall responsible for total generation process and productivity under his jurisdiction.

d) He should inspect, monitor and coordinate, the generation activity of the Corporation and report to the Technical Director.

Eligibility

a) Must be a graduate Electrical/Mechanical Engineer and must have continuous field experience of 20 years service of which 5 years in the field of generation/power plant management in any capacity after graduation and must have served as Senior General manager or its equivalent for 1 year.

b) Must have experience in execution and operation maintenance of power generation projects.

c) He must have attained 30 years of age on the date selection and must have vigilance clearance.

d) He must be physically and mentally fit for holding such responsible post. (Selection by promotion).

GENERAL MANAGER DISTRIBUTION (GRADE E-9)

Responsibility

a) Must be responsible for all distribution related project formulation, evaluation of bids, planning of schedule of maintenance for distribution line/substation.

b) All distribution network maintenances restoration of power supply to consumers and revenue collection and commercial activity related to consumer is his main job.

c) He is to monitor works of all GMS and co-ordinate works of SGMS for proper power flow maintenance.

d) He is to report to the Technical Director.

Eligibility

a) Must be an Electrical Engineer with a valid bachelor's degree in electrical engineering from a recognized Institute/University.

b) Must have 20 years of continuous service experience including in the field of distribution and worked as Senior General Manager or equivalent for one (1) year.

c) Must have experience in execution/operation maintenance work of electrical line & substation including consumer related works and should have attained 42 years of age at the time of selection.

d) He must be physically and mentally fit.

e) Must have vigilance clearance, (selection by promotion).

GENERAL MANAGER COMMERCIAL (GRADE E-9)

Responsibility

a) He will be responsible for all commercial activity, Tariff matters, preparation of tariff proposals, SERC related matters.

b) He is to report to the CMD and the Technical Director.

Eligibility

a) Degree in Electrical Engineering from a recognized Institute/University.

b) Must have continuous service experience of 20 years including 5 years in the field of commercial function and worked as SGM or equivalent for at least 1 year.

c) A person should be physically and mentally fit for holding such post.

d) He should have attained 42 years of age on the date of selection and must have vigilance clearance on date. (Selection by promotion).

GENERAL MANAGER ADMINISTRATION AND HUMAN RESOURCE (GRADE E-9)

Responsibility

a) He is to manage entire administrative machinery of the corporation along with security, public relation, legal affairs and estate management.

b) He is to report to the director Corporate Affairs and the MD.

c) He will be responsible for planning and implementation of all Human Resource (HR) development programme, quality management system, recruitment and posting of staff and officers.

d) He is to report to the Director of Corporate Affairs and the MD.

Eligibility

a) A graduate engineer with adequate knowledge in HRD and aptitude in HR related development work. The person can also a be graduate with preferably MBA/Law degree from a recognized Institute/University.

b) Total 5 years of experience administrative management service (as for instance ACGM/SGM) or equivalent for 2 years, minimum age should be 30 years and there should be vigilance clearance on the date selection.

c) He should be mentally and physically fit for holding such post.

SECRETARY (GRADE E-8)

Responsibility

a) All works related to company affairs, correspondences, preparation of notes for meeting, boards meetings for placement of agenda, notices for meetings, general correspondences preparation for MD.

b) He is to report to MD.

Eligibility

a) Person with degree in any discipline and past company secretary exam from a recognised institute and having at least 5 years experience in company affairs. Knowledge with degree of law will be an added qualification.

b) Must be physically and mentally fit to hold the post. (Selection by recruitment).

CHEMIST – WATER AND COAL SOLUTIONS (GRADE S-5)

Job Description

Testing job in laboratory.

Eligibility

BSc. with Chemistry as subject. Minimum 21 years of age. (Selection by recruitment)

7.1.3 Workman Level Employees Functions of the Project

LABOUR

Table 19: Labour requirements

S/N	DESIGNATION/GRADE	RESPONSIBILITY	ELIGIBILITY
1	**Lineman I Electrician I Substation Operator I Fitter I Mechanic I Welder I (GRADE: W-6)**	Very skilled worker work to be done independently as directed by the supervisor of supervising/junior executives.	1) 5 years experience in the lower grade. 2) Age 25 years for class VIII standard license holder. 3) At least 2 license (Part1 to 5 & 6) in the trade or 40 years for class X pass license holder having 3 licenses in the trade
2	**TEM/Control Room Operator (GRADE: W-6)**	1) All data entry related to the operation and environment of the Plant. 2) Record keeping of official operating data of all plant systems and document them.	1) Graduate Knowledge in computer/operation including documentation of information. 2) Minimum age is 25 years Knowledge of short hand will be added qualification.
3	**Storekeeper (Spares Parts & Scrapes) (GRADE: W-6)**	To receive and to issue materials, keeping material accounts up to date, bin card entry, ledger entry store measurement etc.	1) Secondary Exam Passed. 2) Knowledge in material handling, some training in data entry by computer is desirable. 3) Age above 24 years.
4	**Line man II Electrician II Substation Operator II Fitter II Mechanic II Driver II Technician I Welder II/Blacksmith (GRADE: W-5)**	1) Middle level skilled workman, performing activity in the trade under the supervision of supervisor/Junior Manager related to operation & maintained or construction work (Fuel System, water treatment plant and cooling system, oil system, substations, transformers, electricity evacuation system, etc.) as and when required. 2) Technical job connected to maintenance of line/sub station/power station under the guidance of J/M or manager in charge of work.	1) Class VIII + License (Part VI & VII) in the trade for 2 stage, + 20 years experience in the field of which 5 years in the next worker group, age 38 years (by promotion). 2) Or Class X passed and ITI trade certificate. 3) 15 years working experience in the trade, minimum age 35 years.
5	**Bill Clerk (GRADE: W-5)**	1) Preparation of bill, ledger entry, bill collection work. 2) To read meter and enter in the bill form.	1) Secondary examination passed 6 week training in bill preparation or collection. 2) Class X Pass training in Meter reading job. 3) Age 24 years.

6	**Plumber (GRADE: W-4)**	All connected plumbing job and repairing or refitting of fixtures (oil, gas and water).	1) Class VII standard and certificate in the trade + 3 Years Working Experience. 2) Age above 21 years
7	**Technician III (GRADE: W-3)**	A skilled workman, mainly Conversant with power station/ witch yard work.	Class VIII Standard. 5 year experience as helper I power house.
8	**Helper I (GRADE: W-3)**	Assisting line man/wireman/fitter etc. and independently also allotted some small job and termed as semi skilled labour.	1) Class VIII standard. 2) Minimum age above 25 years. 3) 5 years experience as helper II
9	**Helper II (GRADE: W-3)**	Helping and assisting job attached to lineman, fitter, mechanic, technician etc.	1) Class VIII standard age above 23 years. Physically and mentally fit to do manual job. 2) 5 years working experience as helper –III.
10	**Cleaner I (GRADE: W-2)**	Cleaning Job (office building, including, kitchens, toilets and eatery)	5 years experience as cleaner II
11	**Sweeper I (GRADE: W-2)**	To maintain office/ residential building/ premises clean, landscaping, spraying disinfectant wherever necessary + gardening job	1) 5 years experience as sweeper grade I. 2) Age above 23 years. (Selection by promotion form sweeper II) 3) Preparation of flower bad cultivation of flower garden

SECURITY SERVICES

Table 20: Security services requirements

S/N	DESIGNATION/GRADE	RESPONSIBILITY	ELIGIBILITY
1	**General Manager Security (GRADE: E-7)**	1) He is in charge of security division All security related program, routine security matters of installation including offices to be managed by him. 2) He is to report to the Senior General Manager (Admin) 3) Co-ordinate security related jobs, reporting to GMA – General management Administration.	1) He should be graduate and have post graduate training in security affairs. 2) Must have served for 15 years of which 5 years to be in rank of DGM or equivalent. 3) He should have attained 35 years of age and have vigilance clearness at the time of selection. 4) He should be mentally and physically fit to hold the post. (Selection and not by promotion).
2	**Security Guard (GRADE: W-1)**	1) Guarding security post. 2) Driving Vehicles	1) Class VI pass, min. age 18 years. 2) Class VI pass, min. age 18 years, a valid LMV driving license. 3) Direct recruitment for both posts, the candidates should be mentally and physically fit to hold such post.

NOTE:
Minimum Height of Candidates for the Security services should be 157cm.

7.1.4 Personnel Costs

Table 21: Management cost of the power plant

			Salary [US$ 000.0]	
S/N	Personnel	Qty.	Pers./Mth. [US$]	total/Yr. [US$]
1	Managing Director	1	2.00	24.00
	BOARD LEVEL OFFICERS			
	(XENERGI'S 10.2 MWh IGCC POWER PLANT)			
2	Director Finance & Accounts	1	1.20	14.40
3	Director Technical	1	1.20	14.40
4	Director Corporate Affairs (IEG/IM)	1	1.20	14.40
	T O T A L (II)	**3**	**5.10**	**43.20**

	SUPERVISORY LEVEL EMPLOYEES			
	(XENERGI'S 10.2 MWh IGCC POWER PLANT)			
5	Operations & Maintenance Manager	1	0.85	10
6	Environmental & Safety Manager	1	0.85	10
7	Chemist (Coal and Water Solutions)	1	0.85	10
8	Fuel Manager – Primary & Secondary Fuels	1	0.85	10
9	Power Generation Manager – Powerhouse Equipment	1	0.85	10
10	Power Distribution Manager – Distribut. System	1	0.85	10
	T O T A L (IV)	**6**	**5.10**	**61.20**
	WORKMAN LEVEL EMPLOYEES			
	(XENERGI'S 10.2 MWh IGCC POWER PLANT)			
11	Lineman I (Assistant Electrician)	1	0.45	5.40
12	Electrician I (all Electrotechnical Systems)	1	0.45	5.40
13	Substation Operator I	1	0.45	5.40
14	Fitter I	1	0.45	5.40
15	Mechanic I (Steam Turbine & Related Equipment)	1	0.45	5.40
16	Driver I	1	0.45	5.40
17	Welder I (Assistant Mechanics)	1	0.45	5.40
18	Data Entry Operator	1	0.45	5.40
19	TEM/Control Room Operator (2 x 2p/Sh.)	2	0.45	10.80
20	Storekeeper	1	0.45	5.40
21	Lineman II	1	0.45	5.40
22	Electrician II	1	0.45	5.40
23	Substation Operator II	1	0.45	5.40
24	Fitter II	1	0.45	5.40
25	Mechanic II (Genset & Related Equipment)	1	0.45	5.40
26	Cleaner I	1	0.45	5.40
27	Landscaper (Sweeping & Gardening)	1	0.45	5.40
	T O T A L (V)	**18**	**8.10**	**97.20**
	SECURITY SERVICES			
	(XENERGI'S 10.2 MWh IGCC POWER PLANT)			
28	GM Security	1	1.00	12.00
29	Security Guard I (2 x 3 p/Sh./Plant)	1	0.65	7.80
30	Security Guard II (2 x 3 p/Sh./Plant)	1	0.65	7.80
	T O T A L (VI)	**3**	**2.30**	**27.60**
	G R A N D. T O T A L (US$)	**31**	**21,10**	**253.20**

NOTE:
*For the purpose of this project and based on the international credit or investment requirements, only an operations management cost shall be financed. This means that the Labour Cost for the Operations management of the Plant is **US$ 63,300**.*

7.2 PRODUCTION AND FEED MATERIAL COSTS

7.2.1 Production and Feed Materials Costs

The Production and feed materials consist of Chemicals and Lubricants required for the wastewater Treatment plant, the laboratory, the equipment, etc. The Products will be supplied under CIF basis to aforementioned facilities of the Project.

Chemicals for Water Treatment Plant

Table 22: Water treatment plant chemicals costs

Purpose/Chemicals	Dosing Level [mg/L]	Av. Dosing Level [mg/L]	Unit Price [US$/kg]
Disinfection			
- Primary treatment effluent	5-10	7.50	0.073
- Activated sludge effluent	2-5	3.50	0.073
Chlorine dioxide			
- Primary treatment effluent	2-5	3.50	0.073
- Activated sludge effluent	1-3	2.00	0.073
Ammonia Removal			
Chlorine	10.0	10.00	0.452
Oxidation of Sulphides			
Chlorine	10-15	12.50	0.452
Hydrogen peroxide	1.0-1.5	1.25	0.369
Sodium nitrate	10-30	15.00	0.370
Coagulant Feed			
Aluminium sulphate (alum)	75-150	112.50	0.013
Ferric chloride	45-90	67.50	0.022
Lime	200-400	300	0.514
Ferrous sulphate	>1.5	>1.50	0.110
Ferric sulphate	4-7	5.50	0.110
pH Control (to maintain alcal.)			
CaCO3	100-500	300	0.369
Lime	200-500	350	0.415
Total Average			**0.233**

The Average quantity of chemicals required for the Waster Treatment Plant is approximately 79.50 mg/l at cca. US$0.233 (€0.178) per kg.

Power Plant Lubricants

Lubricants perform the following key functions:

- Keep moving parts apart;
- Reduce friction and transfer heat;
- Carry away contaminants and debris;
- Transmit power;
- Protect against wear;
- Prevent corrosion;
- Seal for gasses;
- Stop the risk of smoke and fire of objects.

The Project will use Perslia (32, 46, 68, 100) TURBINE OILS produced by total. These oils are designed as lubricants of all turbines (steam, gas, hydraulic, etc.) including associated gearbox and control system. These oils are also used for turbo-compressors lubrication.

The features and benefits of these oils are:

- Good anti-corrosion and anti-rust properties;
- Good de-aeration and demulsibility, anti-foaming;
- Anti-wear re-enforced EP capacity;
- Stability against hydrolysis, filterability with or without water

Table 23: Lubricants requirements and costs

S/N	Perslia	Unit	32	46	68	100	Measurement Method
2	Density	kg/m³	885	862	884	886	ISO 3675
3	Viscosity at 40°C	mm²/s	32	46	68	100	ISO 3104
4	Viscosity at 100°C	mm²/s	5.6	6.9	8.7	114	ISO 3104
5	Viscosity index	--	112	106	100	100	ISO 2909
6	Flash Point	°C	220	224	230	250	ISO 2592
7	Pour Point	°C	-20	-18	-9	-9	ISO 3016
8	Demusibility	mm	5	10	<10	<10	ISO 6624
10	**Total**						

Products Specifications:

DIN 51515
JIS K 2213 Type 2 BS 489
ISO-DP 6743/5 Class TSA/TSE/TGA/TGB/TGE
Approved by: GEC ALSTOM, SIEMENS, SKODA, ABB, NUOVO PIGNONE.

It can be estimated that this Power Plant will require 1.63g/KWh Lube Oil Consumption. Therefore, the total quantity of lubricant required for a sustainable operation of the power plant shall be 397.44t/yr. (≈462,620.16l/yr.). The Unit Price of Lubricant is estimated at **US$5.30 (€4.24) per litre.**

The project will not import water, but chemicals (Table 9-2) required for the treatment of raw water. The treated water will be used for the cooling Turbines, Generators, etc. It will also be exported to the Factories within the Industrial Zone of Delta State.

7.2.2 Cost Estimates of Coal Gasification

As already known, solid fuels gasification technology has been understood and applied for a long time. The current directions in developing coal gasification technology are primarily related **to power generation in combined systems involving steam and gas turbine implementation**, which **considerably increases fuel use efficiency**. Compared to the first gasifying installations, the current solutions have a much **higher conversion intensity and are more reliable**. Integrated power generation-related gasification technology developments have created increased interest in chemical products, such as **liquid motor fuels**, **methanol** and **hydrogen**. At the present time, the basic reason for the increase of coal use as a raw material for chemical production is the dynamic industrial growth in countries with high economic potential that do not have their

own natural gas and oil resources or have limited access to international sources of the above minerals. China is a good example of a country in this situation, and it constitutes the largest coal gasifying economy in the world. In China alone, more than 100 million tonnes of coal is gasified yearly, making China the largest importer of modern and advanced IGCC technologies from the EU, USA and Japan, where billion of US$ are granted yearly to energy companies for continual improvement of these technologies to fight climate change and global warming. Actually, most countries in the EU have their coal fired power plants eliminated or transformed to Integrated Gasification Combined Cycle power plants.

During the integrated gasification combined cycle (IGCC, power generation) process, the removal of sulphur compounds (H_2S, COS) is required to **protect the gas turbine**, and CO_2 removal is conducted only to **reduce atmospheric emissions**. However, because of the high concentrations of carbon dioxide and the high-pressure of the treated gas, the removal of CO_2 from syngas (i.e., pre-combustion removal) is less expensive than if the CO_2 were separated from the flue gases (post-combustion removal). Pre-combustion CO_2 removal results in better process and economic efficiency of IGCC systems (in case of CO_2 sequestration) compared to conventional power plants based on coal combustion.

The development state of coal gasification technology

A review of the global development state of gasification technologies has been performed based on a 2010 database developed by the U.S. Department of Energy (US Department of Energy & National Energy Technology Laboratory [US DOE & NETL], 2010a). The results of this analysis have been compared in three categories characterising the current status of technology development: plants that are operational, plants that are under construction (or start-up) and, plants that are in the development phase (this category includes plants in varying degrees of implementation, including plants at the stages of planning, conceptual work and designing). When analysing the data for the various systems, plants that use natural gas as a fuel have been omitted as these plants are not considered to be gasification systems but rather are plants for the partial oxidation of natural gas. The total power of the aforementioned systems (the thermal capacity of syngas output) amounts to 15,281 MWth, of which 72 % (10,936 MWth) is attributed to a plant using a **Shell pressure reactor that is under construction in Qatar**.

The published data show that there are 116 gasification plants equipped with 342 reactors with a total power of 50,104 MWth are currently operating worldwide.

The largest percentage of gasification systems is operating in the Asia and Oceania region (39 % of total global gas production), primarily because of extremely dynamic technology developments in China (78 % of this region). In this region, which includes China, Australia, South Korea and Vietnam, the majority of systems are now under construction and planned for implementation in the next few years. Long-term plans exist for technology development in North America (primarily in the U.S.), the implementation of which would move this region into second place in the global production of gas from gasification (30.4 % of global gas production).

Coal, the basic feedstock for gasification, is used in gasification plants that are currently operating and accounts for 79 % of global gas production (Fig. 1). Petrochemical industry by-products rank second (35.8 %), and the remaining 2.6 % of gas production is attributed to petroleum coke and biomass.

The basic products of operational systems using gasification processes comprise chemicals such as ammonia, hydrogen and oxy-chemicals (46 % of world gas productions), products of Fischer-Tropsch synthesis (30 %), power (16 %) and gaseous fuels (8 %) (Fig. 2).

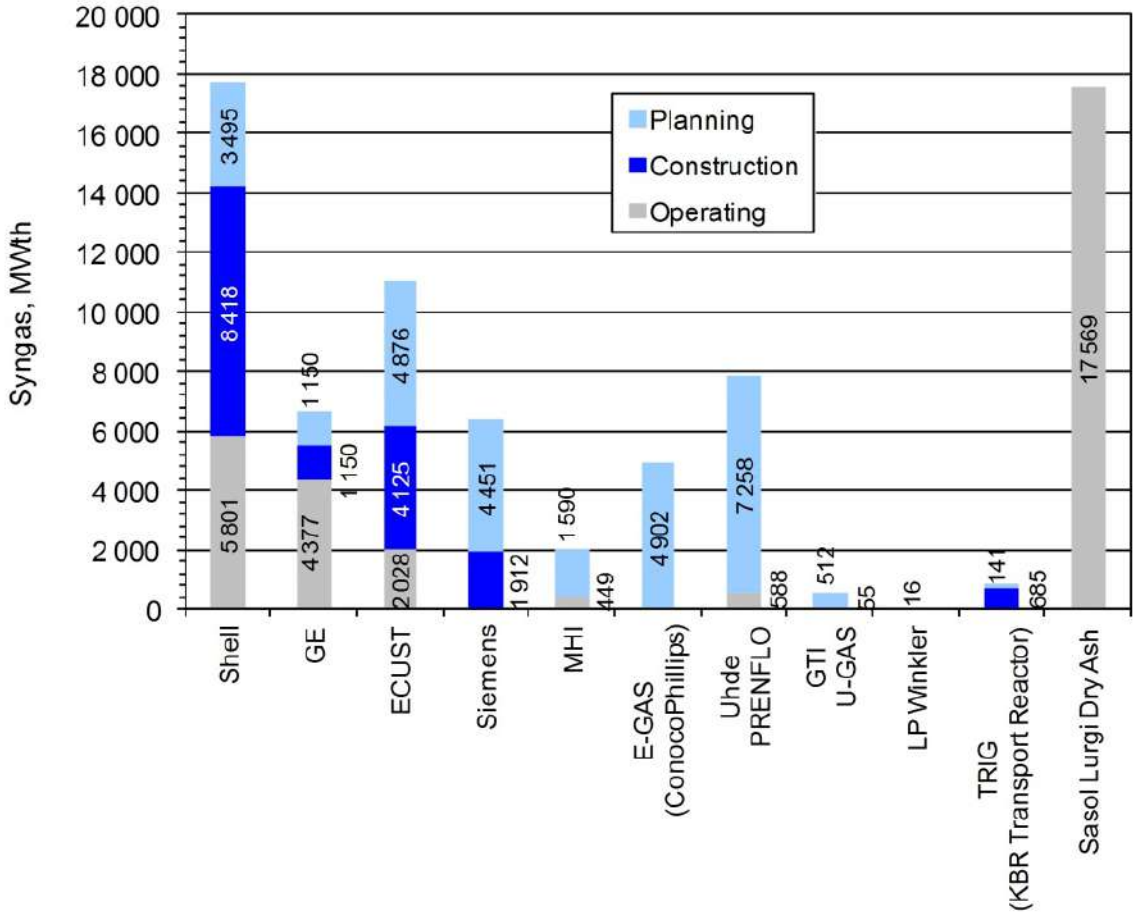

Fig. 21 – Worldwide scheduled, under construction and operating Syngas Projects.

8. MAINTENANCE COST

A general rule of thumb used in the NGSC is to set aside one penny per kilowatt (kW) generated annually for maintenance costs, examples:

If not all of these funds are needed, they could be placed into a contingency account that could grow over the course of operation. In that way, a fund could be created to augment the costs for any major overhaul work or replacement that may have to occur as the system ages.

9. REGULATED ELECTRIC ENERGY TARIFF BY NERC

By these presents the Nigerian Electricity Regulatory Commission (NERC) establishes the schedule of tariffs to be paid each year for the following Nigerian Electricity Supply Industry (NESI) charges over the period 1 July 2008 to 30 June 2013:

- The Wholesale price of generated electricity sold to national grid;
- Transmission charges;
- Retail tariff schedules;
- The Transmission System Operator (SO and MO) charge;
- The PHCN Headquarters charge;
- The regulatory charge; and
- The payment and level of tariff equalisation payments between distributors in order to continue to maintain a national uniform tariff.

The tariff path set for the next 5 years is derived from a regulatory model of the NESI which has been developed from historical industry data and forecasts provided by Power Holding Company of Nigeria (PHCN) and its predecessor and adopted by NERC. This approach forms the basis for a Multi Year Tariff Order (MYTO) based on an industry wide determination of current and future costs.

These regulated charges are established for the period 1 July 2008 to 30 June 2013 pursuant to the authority given under Section 76 of the Electric Power Sector Reform Act (2005).
Retail tariff schedules will be reviewed each year and changes made to the regulated charges if there are material variations greater than plus or minus 5% (in magnitude) in the rate of inflation, exchange rate and cost of gas.

A major review of all inputs to the tariff calculation will be undertaken in 2012 as the basis for a new Multi Year Tariff Order (MYTO) to commence for 5 years from 1 July 2013.

9.1 Background

NERC's commitment and mission is to ensure that electricity is adequate, safe, reliable and affordable.

In January 2006, PHCN requested an average increase in its tariff by 60% from the tariff that had been operative since 2002. The Commission considered this along with the industry's performance over recent years.

The Commission found it necessary to adopt a holistic and scientific approach to correct pricing of electricity over time to ensure gradual sector development through the instrument of a cost reflective and fair tariff regime. The process took into consideration

the interest of consumers and investors simultaneously in addressing the problem of electricity supply and proper pricing of power in Nigeria.

Central to the resolution of the problems of the power sector in Nigeria is the issue of commercial viability of the industry. The industry is barely able to generate enough revenue to cover its operating costs let alone meet its considerable capital expenditure needs. Therefore, the industry is not in a position to attract private sector investment, which is much needed if the twin problems of inadequate and unreliable electricity services are to be tackled.

To this end, the Commission developed a new tariff order for the industry predicated on revenue requirement and sustainability of the incumbent operators and new entrants. While cost-reflectivity is a key consideration in the new tariff order, the Commission is mindful of the impact of any tariff review on consumers.

At the centre of the new tariff order is a multi-year tariff model, which calculates electricity prices based on revenue requirements of the whole industry. This approach is aimed at ensuring the necessary support for operating and capital expenditures of the various sub-sectors i.e. generation, transmission and distribution.

The Commission is introducing a tariff methodology that will aid pricing of electricity in the most reasonable and equitable manner. MYTO will set electricity tariffs for consumers over the 15-year path (1 July 2008 to 30 June 2023). The tariffs are set at levels that support the viability and growth of the Nigerian Electricity Supply Industry (NESI).

To avoid rate shock, the tariffs paid by consumers will be less than cost reflective values over the first three years of the introduction of MYTO. However, Federal Government support will be provided in the form of subsidy to make up the shortfall caused by the difference between actual and cost reflective tariffs over this period, while the tariff moves gradually towards viable levels.

The subsidy is also intended to ensure that the shortfall that arises as a consequence of tariffs being below costs is provided for. Allowing the tariff to reach viable levels over a period of time is expected to lessen the burden on consumers while allowing them to adjust to the new price level overtime. Power availability is also expected to increase during this time. The subsidy is intended to sunset when price reaches the cost reflective level (i.e. in the 4th year).

9.2 Electricity Pricing in Nigeria

In Nigeria, electricity prices are generally lower than the production cost. The tariff was last reviewed in February 2002 (from an average of N4.50/kWh to about N6/kWh) where it has remained to date. In the intervening years inflation in labour and fuel costs and increases in the cost of capital equipment have increased the unit cost of electricity production significantly.

The new tariff order is intended to provide financial incentives for increased investments in the industry and for improvements in plant availability, enhanced metering, billing, and collection performance.

The Commission has over the last one year carried wide consultation with the industry operators, labour unions, consumer advocacy groups, the legislature and relevant Government departments on both the MYTO methodology and tariff.

9.3 Rational for Tariff Review

Electricity is similar to any other manufactured product. Its cost of production is made up of the cost of inputs such as fuel (e.g. natural gas), and capital items such as turbines, cables, switchyards and switching equipment, communication and data acquisition equipment, transformers, and meters. The industry is highly capital intensive and electrical plant and equipment usually have a long technical and economic life, and to complete a project takes a considerable amount of planning, time and effort. Electricity differs from other products in that it cannot be economically stored as it is produced. The implication of instantaneous supply and consumption is that price has to be sufficient to cover the cost of production, otherwise supply will be jeopardised.

If electricity is under-priced then supply will not meet demand. At the moment in Nigeria there is a very high level of unsatisfied demand for electricity due, in part, to the historical under-pricing of electricity. One indicator of this is the extensive use of diesel generators, which typically produce electricity at price levels that are much higher than the price of grid electricity.

It is imperative that electricity should be priced properly such that it covers its supply costs, in order for adequate and reliable electricity is to be produced to meet demand. As with any other product, its price must, at the minimum, cover the operating and capital costs. If the price is at a sufficient level to ensure a reasonable return on investment, it will keep the current producers, and also attract new producers. At present the revenue from electricity tariffs covers about half of the revenue required to achieve a viable and growing electricity sector. In other words, the tariffs currently set for the industry can barely fund routine activities and certainly cannot provide for investment in new generation, transmission and distribution infrastructure.

MYTO 2 is intended purely to facilitate the Industry's successful passage through this period of significant reform, performance improvement and growth. It will:

- Allow for the recovery of appropriate reasonable return on capital invested, depreciation (and replacement) of capital and recovery of fuel, operation, maintenance and overhead costs;
- Provide an incentive for new investment in capital equipment;
- Provide incentives for reducing technical, and commercial losses;
- Provide viable and transparent tariff methodology that will allow NESI's progress towards a reformed and market-oriented system in which generation and retail activities are not subject to price regulation while the monopoly activities of transmission and distribution continue to be under price regulation; and
- Finally, ensure that the benefits of a reformed NESI are passed through to

consumers in the form of reliable electricity supply at the lowest possible price consistent with the above objectives.

The NESI will, as it grows and evolves during the coming years, move to a market- based system whereby generators and electricity retailers will be free to contract with each other for the supply of electricity. Transmission and distribution will remain regulated.

9.4 Legal and Regulatory Frameworks

The establishment of NERC was the direct result of a genuine desire to transform the NESI into a market-based industry. Thus, NERC was established to facilitate the introduction and management of competition in the country's electricity supply industry.

Pursuant to the above, the objects of NERC include:

1) To create, promote, and preserve efficient **industry and market structures**, and to ensure the optimal utilization of resources for the provision of electricity services;

2) To maximize **access** to electricity services, by promoting and facilitating consumer connections to distribution systems in both rural and urban areas;

3) To ensure that an **adequate supply of electricity** is available to consumers;

4) To ensure that the **prices** charged by licensees **are fair** to consumers and are sufficient to allow the licensees to finance their activities and to allow for **reasonable earnings** for efficient operation.

   Section 76(1) of the Act subjects the following activities to tariff regulation:

   a) Generation and trading, in respect of which licences are required pursuant to this Act, and where the NERC considers regulation of prices necessary to prevent abuse of market power; and

   b) Transmission, distribution and system operation, in respect of which licences are required under this Act.

Section 76(2) provides for the NERC to adopt appropriate tariff methodology within the general principles established in the Act, which:

- Allows recovery of efficient cost including a reasonable rate of return;
- Gives incentives to improve efficiency and quality;
- Sends efficient signals to customers on costs they impose on the system; and
- Phases out or reduces cross subsidies.

  This Tariff Order (MYTO 2) is based on a set of principles designed to provide tariffs for each of the generation, transmission, and distribution (including retail)

sectors:

- **Cost recovery/financial viability** – regulated entities should be permitted to recover their "efficient" costs, including a reasonable rate of return on capital.

- **Signals for investment** – prices should encourage an efficient level and nature of investment (e.g., location) in the industry.

- **Certainty and stability** – Confidence in a pricing framework is also important for private sector investment.

- **Efficient use of the network** – Generally, this requires "efficient" prices that reflect the marginal costs that users impose on the system and the reduction of cross-subsidies.

- **Allocation of risk** – pricing arrangements should allocate risks efficiently (generally to those who are best placed to manage them).

- **Simplicity and cost-effectiveness** – the tariff structure and regulatory system should be easy to understand, and not excessively costly to implement (e.g., facilitate metering and billing).

- **Incentives for improving performance** – the way in which prices are regulated should give appropriate incentives for operators to reduce costs and increase quality of service.

- **Transparency/fairness** – prices should be non-discriminatory and transparent, as non-discriminatory access to monopoly networks is also a key pre-requisite for effective competition in the contestable sectors.

- **Flexibility/robustness** – the pricing framework needs to be able to cater for unforeseen changes in circumstances.

- **Social and political objectives** – the pricing framework needs to provide for the achievement of social policy goals such as universal access, demand-side management, and user affordability.

10. PRICING PRINCIPLES

Section 3 of the MYTO Methodology states that "The main objective in setting bulk electricity prices in vesting contracts are to cover the costs of existing plant and allow for their efficient maintenance and on-going investment programs while ensuring that an appropriate price for bulk electricity supplied by generators under vesting contracts is the unit price an efficient new plant would require in the Nigerian Electricity Supply Industry (NESI)." The strategy for managing the transition to a competitive wholesale market includes the use of vesting contracts for generators.

Wholesale contract prices offer the prospect of some certainty about cash flows during the transition towards a competitive market. The method to be used here is the Long Run

Marginal Cost (LRMC) method. LRMC involves calculating the full life cycle cost of the lowest-efficient-cost new entrant generator, taking into account current costs of plant and equipment, return on capital, operation and maintenance, fuel costs, etc. In this Order, LRMC is applied in two ways:

- Benchmark costing: Creates a proxy for the market price, which an efficient generator is expected to operate below.

- Individual long run marginal cost for each generator: This sets prices for each generator according to its plant and site specific costs.

NERC has determined that the price of electricity to be paid to generators will be at the level required by an efficient new entrant to cover its life cycle costs (including its short run fuel and operating costs and its long run return on capital invested). In a market such as the NESI, where demand is in excess of supply, the price of electricity should be at the price required to encourage operators who have already invested into the market, and also attract new entrant investors.

The two methods above will be utilised by the NERC. The classic LRMC applies to the successor Gencos, as set out in the 2008 Tariff Order, in which the long-run marginal cost of an OCGT plant will be calculated for the successor Gencos by the NERC. The individual (site-specific) LRMC model requires each new entrant IPP that requires a tariff beyond the MYTO benchmark to apply to the NERC for approval. In such case, the IPP will open its plans, accounts and financial model to scrutiny by the NERC, which will then apply prudence and relevance tests to determine whether such plant- and site-specific costs should be allowed in the tariff. It is pertinent to note that feed-in tariffs have been developed for investors wishing to invest in generation capacity that utilises other sources of energy including solar, wind, biomass and small hydro.

For the time being, the NERC has determined that the lowest cost new entrant generator is an open-cycle gas turbine (OCGT) using natural gas. Most new power stations completed or under construction are currently open cycle gas turbines. Given the current price of gas used for electricity generation in Nigeria, this form of generation technology produces electricity at a lower life cycle cost than combined- cycle gas turbines, and at a lower cost than coal-fired generation. However, it is anticipated that the gas price will become market-based in the near future, and CCGT is likely to emerge as the benchmark for a lowest-cost new entrant generator. Then, the NERC will review the generation pricing methodology accordingly.

It is to be noted that when the Nigerian electricity market evolves to a point where bilateral contracts are signed between generators and distributors, this LRMC will determine the price set in wholesale contracts. Such bilateral contracts will be executed via the procurement framework now being developed by the NERC. At this point, the wholesale price for each site procured by a Disco or by the Bulk Trader will be the lowest price bid for that site. That lowest price will be the price set in the PPA awarded by the procuring entity.

The selection of OCGT as the lowest price new entrant is in recognition of the fact that natural gas is the most abundant and environmentally-appropriate fuel in Nigeria, and

therefore that which gives Nigerian generators the greatest competitive advantage. New entrants, particularly in a number of locations where natural gas is not most efficient fuel available, are entitled to submit bids for generating plant using the most efficient fuel for that particular site.

The estimation of the generation costs of an open cycle gas turbine power station in Nigeria is based on the estimation of the price required, over the life of such a generation project to pay all of its component costs, including fuel, operation and maintenance, tax and a return on capital. These costs are brought together in a financial model which finds the average price per unit of output that needs to be achieved in order for all of the component costs to be met over the project's life. The component costs are:

- Fuel;
- Capital;
- Fixed and variable operation and maintenance;
- Company tax; and
- Transmission costs.

Other factors that must be determined in calculating the LRMC in this way include conversion efficiency (heat rate) and internal energy use. The capacity factor assumed is important because it determines the output over which fixed costs can be spread. Having determined the values to be assigned to these inputs, they are brought together in a financial model that determines the life cycle price (the LRMC) by calculating a price that makes the net present value of the power station equal to zero.

The methodology is different from the building blocks approach that NERC uses for the calculation of regulated prices for transmission, distribution and retail. In setting the wholesale contract price in this way the NERC is determining a proxy for a market price of generation, not a regulated price, in a way that estimates the price needed to attract the next unit of energy (and the next power station) on to the system. The financial model used to estimate life cycle cost attempts to broadly simulate the financial approach taken by a new entrant when making their investment decision. It includes tax payments, a weighted average cost of capital that reflects generator risks and the effects of other costs, such as an allowance for transmission losses.

At the beginning of the transition stage of the industry, generation output pricing will still be determined by the NERC to ensure that only prudently incurred costs are recoverable. However, it is envisaged that with the imminent introduction of a bulk procurement framework, the market will evolve to having wholesale generation prices set via the bid process albeit benchmarked against the LRMC prices established by the relevant MYTO.

11. EXISTING POWER PURCHASE AGREEMENTS

The pricing of electricity provided by generators to distribution and retail companies through the Nigerian Bulk Electricity Trading Company (Bulk Trader) will be regulated by

the NERC. With the establishment and the operationalization of the Bulk Trader in 2011 and the privatisation of PHCN successor companies now approaching successful conclusion, the Bulk Trader is expected to enter into PPAs with the successor Gencos. The electricity thus purchased will, in turn, be sold to the Discos through a Vesting Contract. This arrangement, while being of utmost importance to the immediate viability of the NESI, is temporary. It will continue for each Disco only until such a time when the NERC, in consultation with relevant stakeholders, determines that the Disco has become financially viable and is able to contract for new capacity on its own account and also to take over (novate) these existing PPAs with the Gencos.

The Bulk Trader's PPAs with successor Gencos provide the NESI with a commercially sensible way to provide payment security, reassign payment risks, provide a guarantee of supply to the Discos and, above all, incentivise the legacy Gencos to immediately commence recovering their licensed capacities that have remained stranded for decades (estimated at about 3,000 MW) because of their inability to earn enough income to justify necessary capital expenditure.

12. TECHNICAL ASSUMPTIONS FOR THE DETERMINATION OF THE LRMC FOR 2012 TARIFF ORDER

12.1 Introduction

The 2012 Tariff Order determined that the generation price is to be based on efficient new entrant life cycle costs and this price is to be paid to all generators who sell to the grid. Further to this, it was determined that this new entrant will be an Open Cycle Gas Turbine Plant (OCGT). To further open the market and encourage other sources of fuel, the NERC has allowed for coal-fired plants, renewable energy plants, and has also developed a separate LRMC for large hydro plants.

The OCGT plant, chosen due to the abundance of gas in Nigeria at a relatively low price, is regarded as one of the most efficient plants, and all new entrants are to use this efficient technology benchmark for project evaluation and analysis.

12.2 Coal-To-Power Plants – NERC's Subcritical Water-cooled Plant case

The NERC has developed the methodology for deriving the Long Run Marginal Cost (LRMC) or the life cycle cost of a coal-fired generating plant in Nigeria. This is aimed at taking advantage of the abundant coal resources in the country, and also opening up the market to give investors in power generation more choices.

For coal-fired generation in Nigeria, two possible sources of coal are considered, namely; domestic and imported coal. The consideration for an imported coal source may be a short-term measure pending when coal mines become fully operational in Nigeria. However, the price is benchmarked to imported coal (landing cost) to encourage local mining, while discouraging importation.

The explanations of the assumptions considered in the LRMC for coal are as follows:

- ***Thermal efficiency:*** The estimates of heat rate have been based on sent out and generated output published by existing black coal generators in Australia and Asia. NERC considers **forty-two percent (42%)** as appropriate, as it takes into account the average plant heat rate, ageing, load frequency of starts and lifetime extension.

- ***Plant Availability:*** Availability is the proportion of time in any operational year that a plant is available to generate. The outage times that reduce availability consists of planned outages for scheduled maintenance and forced outages when plants are forced to stop or operate at reduced output for technical reasons. Data on new plants and technologies indicate that outage rates can be high and so availability for a new Integrated Gasification Combined Cycle (IGCC) Power Plant is estimated at **86%**. This plant is designed to supply electricity to the Enpower Free Trade Zone (EFTZ) 24/7 *i.e.* a Total Number of Operating Hours (NOH) of **8,760 hours/ year**.
- ***Construction period:*** The construction period or build time assumed for this **10.2 MWh IGCC** power plant is **1-2 years**.

- ***Variable Maintenance Cost:*** Variable Maintenance cost is the parts and labour expenses of maintaining equipment and facilities in satisfactory operating condition (only expenses incurred as a result of electric production qualify for inclusion in this cost). The assumed Variable Maintenance of this 10.2 MWh IGCC Power Plant is **US$1.88 / MWh**.

- ***Construction period:*** The time it takes to complete and commission the plant is **12-24 months**, starting from **June 2022**.

- ***Plant life Cycle:*** This is the life over which costs are recovered and for the purpose of calculating the long run marginal cost of a new plant. **The project life of Five (5) years has been set**.

- ***Capacity factor:*** NERC has continued to adopt the approach of setting the plant factor based on the actual performance of the most efficient subcritical black coal generator. The **capacity factor has been set at 70%**. New plants will have a high level of availability and so should be running at maximum output for a high proportion of the time in order to meet demand.

- ***Auxiliary/Internal usage:*** The subcritical black coal plant will require a water-cooling system; therefore, the auxiliary is estimated at **7.5%**.

- ***Capital Cost:*** The estimate of project capital cost for a new coal-fired power station includes the following components:

    - Engineering, Procurement and Construction (EPC);
    - Planning and approval;
    - Professional services;
    - Land acquisition;
    - Infrastructure costs (including water);
    - Spares and workshop, etc.;
    - Connection to the electricity transmission network; and
    - Fuel connection, handling and storage

- The estimate of the project capital cost excludes Interest During Construction (IDC), capital costs, and site works for a coal mine. IDC is excluded, as a return on investment is required in this model from year zero (i.e., at the commencement of the project before construction has begun) and interest charges are a component of the WACC.

13. ECONOMIC AND FINANCIAL ASSUMPTIONS FOR THE 2012 TARIFF ORDER

13.1 Introduction

To develop the tariffs, a considerable mass of economic and financial assumptions were made by the regulator as the basis of the Tariff Order. These include the following variables.

13.2 Inflation

As of today, 9 December 2021, the Nigeria's inflation rate hits 18.75%, which shall be adopted in this study (see CBN). This however, is subject to minor review bi-annually. In an event of any material change in inflation rate, this would be reflected and the tariff adjusted accordingly.

In the MYTO, the rate of inflation is used to ensure that investors are well compensated against rising cost of doing business and workers in the industry are paid living wages. To achieve this, the NERC has escalated the following variables:

- WACC;
- Fixed labour cost;
- Fixed admin cost;
- Variable O&M cost;
- Other Fixed O&M cost; and
- Capital Investment.

Table 24: Assumed inflation rate in Nigeria (2021-2032)

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Inflation	18.75	18.75	18.75	18.75	18.75	18.75	18.75	18.75	18.75	18.75	18.75	18.75

13.3 Exchange Rate (ref. CBN rate)

Being an importer of electricity generation equipment components opens Nigeria to foreign exchange risk. This foreign exchange risk is taken care of in the MYTO model, and adjusted bi-annually during the minor reviews.

Though this is regularly adjusted during the minor reviews to bring it to current realities, investors have informed the NERC that the official CBN rates are not always accessible to them, and that they are often charged a commission. NERC therefore recommends a 1% premium above CBN rates. The exchange rate adopted is assumed to increase steadily over the years, and is also subject to review bi-annually.

Table 25: Assumed Naira/US Dollar Exchange Rate (2021-2032)

Years	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Exchange Rate (US$)	409.7	417.7	426.7	437.7	446.7	455.5	464.9	474.3	483.7	493.1	502.5	511.9

13.4 The Weighted Average Cost of Capital (WACC)

The cost of capital included in the MYTO is intended to provide a return on existing assets and appropriate incentives for future investment. The cost of capital is an important component of the tariff and is included in the annual revenue requirement calculation as a return on the value of capital invested. The regulated asset value at the start of a given year is calculated by taking the depreciated replacement cost of capital assets at the start of the immediate proceeding twelve (12) months, and adding the investments in new capital assets acquired during the same period.

The Capital Asset Pricing Model (CAPM) is used to estimate a WACC for the NESI. While this approach gives a method for estimating the average cost of capital in a sector and is widely used by regulators, it requires consideration of volatility of returns in the sector, as well as the domestic cost of debt. Even in developed economies, the calculation of a WACC frequently requires estimation of a number of the inputs. This is the case in Nigeria, and most of the inputs to the WACC calculation are, the NERC estimates. The WACC is set at the level that attracts investment funds to the industry, but is not sufficient to produce super profits.

The CAPM provides estimates of the appropriate return on equity and the returns to equity are measured in relation to the risk premium on the equity market as a whole. Thus:

$$Re = Rf + ße\ (Rm - Rf) \qquad (2)$$

Where:

Re is the return on equity is the risk-free rate observed in the market
Rf is the return on equity is the risk-free rate observed in the market
ße is the correlation between the equity risk and overall market risk
Rm is the return on the market portfolio
Rm – Rf is the market risk premium
The WACC lies between the cost of equity and the cost of debt. The WACC is calculated as:

$$WACC = Rd \times D/(D + E) + Re \times E/(D + E) \qquad (3)$$

Where:

D is the total market value of debt
E is the total market value of equity
Rd is the nominal cost of debt; and

Re is the nominal cost of equity.

This formulation does not include the effects of tax. The formulation of the WACC that allows for the effects of taxation – specifically the corporation tax rate (Tc) – and used extensively by regulators is as follows:

Nominal post tax WACC (w) = Re x E/V + Rd (1 - Tc) x D/V (4)

Where:

T_C is the company tax rate,
V is the total market value of the business, i.e. debt plus equity

A transformation is applied to derive an estimate of the real pre-tax WACC, as follows:

Real pretax WACC (RW) = [(1+w/(1-Tc))/(1+i)] -1 (5)

Where:

W is the nominal post tax WACC, as given by equation (4)
I is the inflation rate

The company tax rate used is the statutory corporation rate of 32%.

13.5 Estimating the WACC Components

This section provides the NERC's estimates of the various components required to calculate a WACC for the NESI. These estimates are then drawn together in a description of the process used for the first WACC calculation.

❑ The Risk Free Rate

The yield on government bonds is regarded here as the risk free rate. The NERC has had regard to relevant yields on Nigerian Treasury bonds, and has selected a risk-free rate of 18%.

Many regulators use 10-year bond rates or 10-year (indexed linked) bonds or their local equivalent. The longer term also ensures consistency with the risk free rate used to estimate the market risk premium – that is also based on 10-year bonds.

❑ The Cost of Debt

The NERC adopted a nominal cost of debt of 24% for generation reflecting current debt levels for business and project. The cost of debt is generally determined by adding a debt premium, and sometimes a transaction cost, to the risk free rate.

Rd = Rf +DRP+DIC (6)

Where:

DRP is the debt risk premium
DIC is the debt issuance cost lending in Nigeria

❑ Betas

Beta reflects the riskiness of an asset relative to the market as a whole (usually represented by the stock market). Equity betas will reflect the financial risk carried by shareholders, which is in turn influenced by the level of gearing since high levels of debt increase the risk to shareholders.

Electricity supply is not an area with any history of investment from which to draw information on the relative risk and it is not considered possible to derive at statistically significant betas. The NERC has decided not to apply any value for the 2012 Tariff Order, but appropriate estimates will be made against next tariff review when enough data exists for estimates to be made.

❑ Gearing

The ratio of equity and debt is used to weight the equity and debt returns in the WACC calculation.

In the past, independent power producers in developing countries were financed with high gearing ratios – commonly 80:20 debt to equity. However, the World Bank considers that in future, greater caution by lenders will result in project sponsors being expected to assume a greater degree of the project risk, by accepting lower debt-equity ratios. The Bank has suggested that future ratios would be closer to 60:40. This level would also apply to regulated assets, such as transmission and distribution.

The NERC has selected a gearing ratio of 70:30 in the development of the WACC for the NESI.

❑ WACC estimate

The following are the main assumptions used in the WACC calculations:

- risk free rate 18%
- nominal return on equity 29%
- nominal cost of debt 24%
- gearing level (debt/equity) 70%/30%

- corporate tax rate 32%

These assumptions provide the following WACC estimates:

- Nominal before tax WACC 25%
- Nominal after tax WACC 17%
- Real pre-tax WACC 11%
- Real after tax WACC 7%

13.6 Tariff for Coal Power Plant

Tables 25 below shows the wholesale prices calculated through the LRMC of thermal power plants (from natural gas fuel) for each year of the coming tariff period. As the NESI evolves, more credible and detailed data on industry performance will become available, and the renewables sub-sector becomes more viable with the emergence of cheaper technologies and a settled Government policy, NERC will review its assumptions particularly as regards renewable.

The total wholesale contract price has been calculated for each year as a capacity and an energy charge. The capacity charge comprises fixed operation and maintenance cost, capital cost and two-third of tax (2/3) cost. While the energy charge comprises fuel cost, variable operation and maintenance cost, the transmission loss cost and a third (1/3) of tax cost. The capacity and energy charge will be included in the wholesale contract and will be the basis for payments to the eligible generators.

However renewable energy generators are not entitled to capacity payment but will be paid full wholesale price based on power sent out from their plants.

Table 26: Wholesale Generation Prices for New Entrants IGCC Power based on MYTO 2012

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Wholesale contract prices (US$/MWh)	156.9	168.9	181.9	197.3	214.0	223.1	236.6	250.0	263.4	276.8	290.3	**303.6**
Capacity charge (US$'000/MW/month)	87.3	94.4	102.1	110.3	119.3	125.4	133.1	140.7	148.4	156.1	163.7	**171.4**
Energy charge (US$/MWh)	69.6	74.5	79.8	86.9	94.7	97.2	103.0	108.7	114.4	120.1	125.9	**131.6**

14. TOTAL PROJECT INCOMES

14.1 Electric Energy

Based on the MYTO II (2012) of NERC, we are considering the lowest electric energy unit price to be fixed at **US$197.30/MWh (€143.75/MWh)**[15] starting from **June 2023**, commissioning year of the Power plant. This price is considered to be the actual basic price and shall increase within the next coming years. For the purpose of this study, we are considering this unit price fixed in the event of change of laws and unstable economy.

[15] 1 Euro = USD1.3746 (May 8, 2014 – Euro-US Dollar Exchange Rate – *Source Bloomberg*)

The pricing regime developed by NERC and embodied in the Multi-Year Tariff Order – MYTO approach is intended to facilitate the industry's successful passage through a period of significant performance improvement and growth. This developed NERC order will:

- Allow for the recovery of an appropriate return on capital invested, depreciation (and replacement) of capital and recovery of fuel, operation, maintenance and overhead cost;
- Provide an incentive for new investment in capital equipment;
- Provide incentives for reducing technical and non-technical losses, lowering forced outages and levels of unsaved energy;
- Provide viable and transparent tariff order methodology;
- Finally, ensure that the benefits of a reformed NESI (Nigerian Electricity Supply Industry) are passed through to all consumers in the form of reliable electricity at lowest possible price consistent with the above objectives.

Since demand is in excess of supply the price of electricity should be at the price required to attract new entrant investors into the market. This price will be paid to all generators who sell to the national grid except those who hold Power Purchase Agreement (PPAs).

NOTE:
The wholesale generation tariff was considered to be fixed at **US$197.30/MWh (€143.75/MWh)**[16] *– Selling Price from June 2023 pursuant to NERC MYTO II 2012.* This price shall be applicable in the case the bulk purchaser, herein called the Nigerian Bulk Electricity Trading Company (NBETC) and/or the Enugu Electricity Distribution Company (NEDC) shall be purchased the whole generated net power.

This is a case study of embedded power generation, which shall be sustainably supplied to the consumers (residential, commercial and industrial) of Enpower Free Trade Zone as Captive Power Supply *i.e.* 24 hours/day and 7 days/week.

15. CONCLUSION

The results of the studies have shown that the Project is technical and economically viable even when operating at 60% of its Net Output Capacity of 10,200.50 kWh. (≈10MWh) at the lowest and regulated price possible of lowest electric energy unit price to be fixed at **US$197.30/MWh (€143.75/MWh)**[17] (price used in this study), starting from June 2023. Besides, another very important techno-economic factor, which is the Captive Power Generation design model, would also be taken into consideration. Electricity shall be supplied to all EFTZ's Companies under a Captive Power Purchase Agreement (CPPA) of **€ 0.1438/kWh**[18] minimum, which is twice higher than the regulated price given by the Nigerian Electricity Regulatory Commission (NERC) under the Multi Year Tariff Order (MYTO II) used in this Feasibility Study. This MYTO II is based on a set of principles designed to provide tariffs for each of the generation, transmission, and distribution (including retail) sectors:

[16] 1 Euro = US$1.3746 (May 8, 2014 – Euro-US Dollar Exchange Rate – *Source Bloomberg*)
[17] 1 Euro = US$1.3746 (May 8, 2014 – Euro-US Dollar Exchange Rate – *Source Bloomberg*)
[18] Captive Power Purchase Agreement Price – this Price is not used in this study.

- **Cost recovery/financial viability** – regulated entities should be permitted to recover their "efficient" costs, including a reasonable rate of return on capital.

- **Signals for investment** – prices should encourage an efficient level and nature of investment (e.g., location) in the industry.

- **Certainty and stability** – Confidence in a pricing framework is also important for private sector investment.

- **Efficient use of the network** – Generally, this requires "efficient" prices that reflect the marginal costs that users impose on the system and the reduction of cross-subsidies.

- **Allocation of risk** – pricing arrangements should allocate risks efficiently (generally to those who are best placed to manage them).

- **Simplicity and cost-effectiveness** – the tariff structure and regulatory system should be easy to understand, and not excessively costly to implement (e.g., facilitate metering and billing).

- **Incentives for improving performance** – the way in which prices are regulated should give appropriate incentives for operators to reduce costs and increase quality of service.

- **Transparency/fairness** – prices should be non-discriminatory and transparent, as non-discriminatory access to monopoly networks is also a key pre-requisite for effective competition in the contestable sectors.

- **Flexibility/robustness** – the pricing framework needs to be able to cater for unforeseen changes in circumstances.

- **Social and political objectives** – the pricing framework needs to provide for the achievement of social policy goals such as universal access, demand-side management, and user affordability.

In the MYTO, the rate of inflation is used to ensure that investors are well compensated against rising cost of doing business and workers in the industry are paid living wages. To achieve this, the NERC has escalated the following variables:

- WACC;
- Fixed labour cost;
- Fixed admin cost;
- Variable O&M cost;
- Other Fixed O&M cost; and
- Capital Investment.

As already stated above, the Total Investment Capital (TIC) for the construction of the XENERGI's embedded 10MWh IGCC power plant is estimated at **€ 17.25 Million**. This

TIC does not include the cost of the integrated electricity distribution network (33kVA, 11kVA, and 0.4 kVA lines).

The Total Investment Capital (TIC), as usual, always include the reimbursable required for the development (pre-operational cost), the costs for the delivery of technologies and equipment under cost, insurance and freight (CIF) basis to the power plant construction site and a 3-month operations management cost.

Table 27: Project financing

PARAMETERS	DATA
Debt ratio (%)	85.00
Equity ratio (%)	15.00
Fixed Interest Rate on Debt (%/y)	5.00
Economic Life (y)	5
Total Investment Capital (€)	17,245,871.00
Total Equity Value (€)	2,586,881.00
Total Debt Value (€)	14,658,990.00
Capital Recovery Factor (Equity)	0.2983
Capital Recovery Factor (Debt)	0.2310
Annual Equity Recovery (€/y)	771,707
Annual Debt Payment (€/y)	3,385,857
Debt Reserve ($)	3,385,857

The reimbursement of the loan provided by the Czech Export Bank, a.s. (CEB) for a period of 5 years is provided as follow:

Table 28: Loan reimbursement schedule

Reimbursement Period	Year 1	Year 2	Year 3	Year 4	Year 5
Debt Principal Paid (€)	3,032,178	3,183,787	3,342,977	3,510,125	3,685,632
Debt Principal Remaining (€)	13,722,521	10,538,734	7,195,757	3,685,632	0

The **XENERGI 's Thermal Power Project** will produce substantial benefits for the Nigerian national economy and local communities near the site. In addition to direct benefits – new jobs, lower electricity costs, etc. – the project will stimulate increased economic activity, producing important "macro" benefits for the national community.

The Project will lay emphasis on the Transfer of Know-How: Training of youth to carry out the future Operation Managements, including schedule and unscheduled maintenance of the Power Plant. ISTROENERGO INTERNATIONAL, A.S. has agreed to involve the local content from labour to expertise works before and during the construction of the Plant. Through this Project, XENERGI LIMITED is seeking a long-time cooperation with the Czech Companies in the training of the young Nigerians for operations management and maintenance of the Company's energy and power facilities independently.

This Project will considerably contribute in the improving local communities. The facility is benefiting the residents and economies of local communities located near the project site. New jobs, primarily unskilled and semi-skilled, are creating employment opportunities for Enugu State workers. In addition to improving the local economy, XENERGI LIMITED is committed to preserving the heritage and cultures of nearby villages. Meetings with the local communities and authorities will help XENERGI LIMITED

identify actions needed to fulfil that commitment.

An estimated 50-100, workers will be employed at peak times during the 12-15 months construction period. In recruiting workers, our project team is giving preference to local residents living in the area near the project. This increase in employment will stimulate the local economy, leading to investment in new and existing businesses and additional job opportunities for local residents.

XENERGI LTD is committed to providing additional sustainable benefits, primarily for the local communities affected by the project. Our Community Development Action Plan supports long-term development initiatives of communities. **This will create a new market and business opportunities for Czech Investors**. The major features of our community development plan include:

- improve local facilities, such as:
  - Enhanced water supply;
  - Better schools; and
  - Enhanced health care facilities.

- Support sustainable economic development through:
  - Enhanced job creation and worker training;
  - Improved agricultural productivity and marketing;
  - Promotion of other business activities;
  - Enhanced fishing activity; and
  - Support for vulnerable people.

- Tourism initiatives.

16. PROJECT ORGANIZATIONAL STRUCTURE

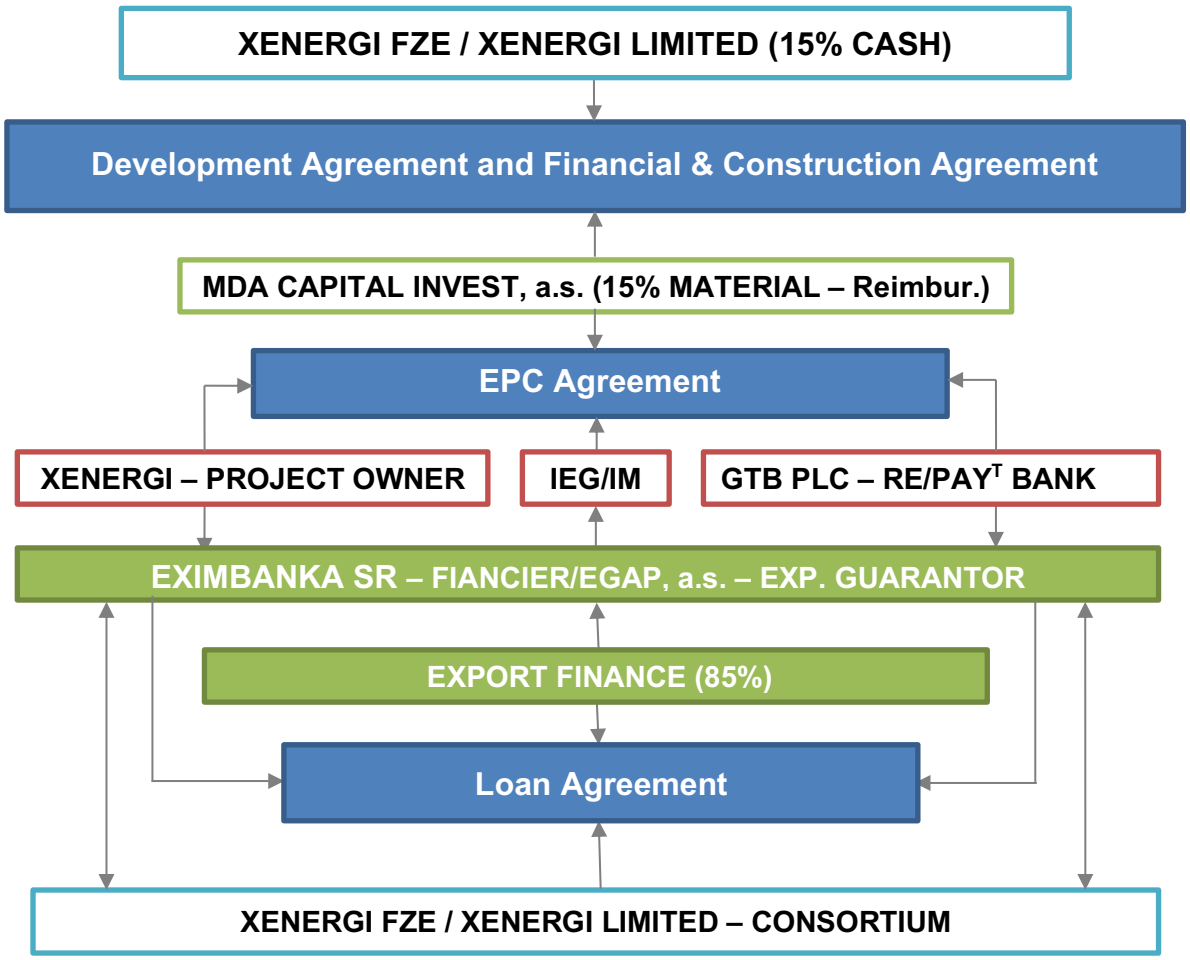

Fig. 22 – Project organizational structure

NOTE:
The EPC Contractor, ISTROENERGO INTERNATIONAL, A.S. (IEI), shall provide a Performance Bond (PB) of 2% (Two percent) maximum of the contract sum (EPCI Agreement) and guarantee the executed part of the Project or operation of installed technologies for a period of Two (2) pursuant to ICC Publication No. 458, INCOTERMS 2000. This condition shall be included in the EPCI Agreement.

Concerning the local Contractors or Suppliers, an Advanced Payment Guarantee (APG) of the equivalence of the Total Mobilization Fee (TMF) shall be provided by their own appointed local banks. The terms and conditions of the returning back of the APG to Contractors or Suppliers shall be negotiation in the EPCI Agreement.

17. PROJECT ENTITIES

17.1 PROJECT COMPANY

17.1.1 XENERGI LIMITED

XENERGI LTD (aka XENERGI), hereinafter referred to as the Project Company, is a Nigerian energy Company, which is engaged in developing, building, owning and operating energy and electric power facilities. One of the Energy assets of XENERGI the Ebendo Gas Plant. XENERGI shall form a Special Purpose Vehicle (SPV), regrouping a group of investors under a **Joint-Venture Agreement** to secure the necessary financial

equity, including the 15% equity share required by the financier for financing the Engineering, Procurement, Construction and Management (EPCM) of the Project.

XENERGI LIMITED is headquartered at Plot 282b Trans-Amadi Industrial Estate, Port Harcourt, Rivers State, Nigeria (headquarters for Africa). It has also other headquarters in USA (for America) and India (for the Middle-East).

XENERGI LIMITED is also established for the following objectives:

1) To develop, build, own and operation energy resources (mining, oil & gas, etc.), properties, estates, transportation systems (air, sea, and ground transportation systems); water treatment plant, amusement parks, recreational areas, warehouses and shops;

2) To carry on any business within the area of Nigeria as the Authority may permit under the terms of the license issued to the Company as may amended from time to time by Nigerian Authority;

3) to develop, manufacture, repair, modify, sale and engage in leasing of air, sea, and ground vehicles;

4) to market refined petroleum products (Filling stations and Storage facilities);

5) to provide technical, economic and management consulting services;

6) to build, fabricate, develop, maintain, repair, design, architectural, electrical and structural facilities;

7) to acquire all licenses, concessions, grants, permits and powers necessary to offer telecommunication technologies and systems services intended to be used for purposes of and in connection with business of the Company;

8) to borrow, grant security, guarantee any obligation or any person as may be necessary in the course of carrying out the business of the Company;

9) to draw, make, accept, endorse, discount, negotiate, execute and issue promissory notes, bills of exchange, bill of lading, warrants, debentures and other negotiate and transferable instruments;

10) to apply for, promote and obtain any Act of National, charter, privilege, concession, license or authorization of any government, state or municipality, or any other department of authority, or enter into arrangements with any such body, for enabling the Enterprise to carry out any of its objects into effect or for effecting any modification of the constitution of the Enterprise or of any other purpose which may seem to the Board of Directors to be expedient, and

11) to oppose any proceedings or application, which may seem calculated directly or indirectly to prejudice the interest of the Company;

12) to any for any rights or property acquired by the Company and to remunerate any person or enterprise, whether by cash payment or by the allotment of shares, debentures or other securities of the Company credited as paid up in full or in part, or by any other method the board of director thinks;

13) to co-ordinate, finance and manage all or any part of the operations of any enterprise which is a subsidiary Company of or otherwise under the control of the Company and generally to carry on the business of a holding Company;

14) to carry on through any subsidiary or associated Company any activities which the Company is authorized to carry on and to make any arrangement whatsoever with such Company (including any arrangements for taking the profits or bearing the losses of any such activities) as the Board of Directors thinks fit.

17.2 TECHNICAL CONSORTIUM

17.2.1 MDA CAPITAL INVEST, A.S

MDA CAPITAL INVEST, A.S. (MDACI) is a Czech Joint Stock Investment and Export Support Company, whose primary business activity is to support the export of Slovak products by helping domestic manufacturers to increase sales and profits, reduce dependence on the domestic and European markets and stabilize seasonal fluctuations. MDACI main partners are the Export-Import Bank of Slovak Republic (EXIMBANKA SR) (financier) and the Export Guarantee and Insurance Corporation, a.s. (EGAP) (credit insurance corporation). MDACI focuses on the newly developed export markets, consisting of Africa, South America, Asia and the Middle East.

MDACI's main business activities include:

- Energy (petroleum products including renewable energy, and mining);
- Power (generation, transmission and distribution);
- Infrastructure (transportation technologies, transportation systems and ITC, security, roads, railways, water ways, airports, etc.);
- Health (hospitals, medical technologies, cosmetics, etc.);
- Agriculture (agricultural technologies and products); and
- Educational Services (trainings & education);

EUROMADE ENGINEERING AND CONSTRUCTION COMPNY (EUMEC) is a subsidiary of MDACI, which is a civil engineering company established in Nigeria. The Company is a formed by a group EU engineering and Construction Companies, which shall secure all the necessary technical expertise and civil engineering works of the projects developed by MDACI Consortium in Nigeria and in Africa.

As the Project Developer, MDACI/MDACI Consortium's Scope of Works described within this section is specifically for those projects that employ the Conventional Project Delivery Method *(Design-Award-Construct-Install-Inspect-Commission-Deliver)* defined as follows:

a) The Developer shall be responsible for the data collection necessary for the technical design (architectural, structural, mechanical, electrical design) and quality and quantity surveys of the main parts of the Projects (Buildings, Roads, Bridges, Canalizations, Wastewater Treatment Plant, etc.), which satisfies the project specifications, consistent with all the relevant statutory and other *STANDARDS* and guidance, and is within approved *COST,* and on *TIME.* The Developer shall be responsible for the direction and co-ordination of the work of all the Contractors, Consultants, and Sub-consultants in the team to the end.

b) The Developer shall furnish all the general and specific requirements necessary for the development and Construction of the whole project.

c) The Developer shall ensure the Pre-feasibility and Full Feasibility Studies reports of each of the Projects Phases and coordinate the Environmental Impact Assessment Studies with the State Ministry of Environment, the Evacuation Studies (if required), permits and licenses with the relevant government agencies.

d) The Developer shall faithfully carry out the duties, which they undertake. The Developer shall also have a proper regard for the interests of both Enugu State Government and those who may be expected to use the project of his work.

e) The Developer must be guided in all professional relations by the highest standards of integrity.

f) The Developer shall make sure that all Contractors, Consultants and Sub-Consultant are duly qualified for the execution of their contracts. The Selection of these Contractors, Consultants and Sub-consultants shall be performed in full due process and corruption free.

g) The Developer shall be the only exclusive responsible for the financial strategy planning of the Project with the aforementioned local and foreign Banks, and other foreign and local investors. The operational business for the purpose of this Project shall be located in Abuja and in Enugu (Enugu State).

h) The Developer shall represent the building sponsors and assume responsibility for the planning, operation and management of the whole Project up to completion.

i) As the Project Company's representative, the Developer prepare proposed solutions, adaptive measures and decisions, provide encouragement and advice, explain, take care of records and documentation, analyse risk and guarantee security for the building security.

j) When conflicts arise, the Developer negotiates with those involved and is often able to introduce situation-specific, problem-solving alternatives, which satisfy both parties. If necessary the Developer will work together with experts in the field of

mediation. Mediation is an effective method for obtaining a solution satisfactory to both of the Parties in conflict. The decision factor in the process is the constant participation of the mediator, who functions exclusively as a go-between for the parties.

MDACI is responsible for the development of the Project, carrying the following services for bankability and construction of the Power Plant:

1) Technical Services;
2) Financial Services; and
3) Legal Services.

17.2.2 EUROMADE ENGINEERING & CONSTRUCTION LIMITED

EUMEC, a Consortium of MDA CAPITAL INVEST, A.S. (MDACI) was founded because of the Africa's need for high quality and standards civil objects (houses, road, bridges, power plants, refineries, gas plants, oil & gas storage and distribution pipelines, water treatment plant and distribution networks), environmental restoration, stewardship, and protection of neglected public lands. One of the main objectives of EUMEC is to secure the necessary technical expertise and civil engineering works of the projects developed by MDACI Consortium in Nigeria. While carrying out its engineering and construction works, EUMEC utilizes the resources of the community to provide long-term environmental benefits for natural areas without neglecting the diverse strengths of different ethnics and cultures to accomplish our common goal of restoring the beauty of the natural landscape. We always lay emphasis on design and construction precision, high quality and standards at fair cost. **EUMEC shall be responsible for the Design and Construction of the whole power plant**, including the following civil objects:

1) CF1 – Access roads external and internal roads)
2) CF2 – Main entrance and security post
3) CF3 – Administration and operations management building
4) CF4 – Coal receiving, storage and handling facilities
5) CF5 – Storeroom and maintenance workshop
6) CF6 – Wastewater treatment plant
7) CF7 – Powerhouse
8) CF8 – Stacks / Exhaust ducts
9) CF9 – Raw and clean water storage tanks (concrete)
10) CF10 – Backup gas supply tanks
11) CF11 – Power generation and distribution control room
12) CF12 – Coal gasifier

17.2.3 ISTROENERGO INTERNATIONAL, A.S.

ISTROENERGO INTERNATIONAL, A.S. (IEI) shall be lead and main engineering, procurement, construction (EPC) contractor. It is responsible for engaging and selecting the sub-contractors in cooperation with MDA CAPITAL INVEST, A.S. (Developer). Each subcontractor shall provide a 2% Performance Bond (PB) of the total equivalent subcontract value and a 2-year (24 months) operational warrantee to IEI. The main local subcontractor, member of MDACI Consortium, is EUROMADE ENGINEERING AND

CONSTRUCTION LIMITED, which shall be responsible for the Civil Engineering part of the Project. EUROMADE ENGINEERING AND CONSTRUCTION LIMITED is a member company and subsidiary (60% of the total share capital) of MDACI Consortium. *See section 1.5.1.2.2 above*.

IEI is one of the biggest Slovak and Czech suppliers of power generation projects and their technological parts.

IEI supplies power generation projects from the design through implementation and assembly to commissioning and securing of both warranty and extended warranty service. The Company is also very active in the reconstruction of existing plants and the supply of balance of plant and services.

IEI is a modern and dynamic corporation operating in Slovakia and in the Czech Republic. IEI is engaged in the business of industrial projects, civic projects, power and energy (petrochemical projects).

In any kind of energy production, the production from fossil fuels is still dominating because of the worldwide reserves, availability and competitiveness. Conversion of the fossil fuels energy to the utilizable form of electric or thermal energy is carried out in thermal power plants and heat stations. Considering the continuous increase of energy consumption worldwide the new thermal power plants and heat stations are being built. Furthermore, the less effective and outdated plants are being substituted by newer ones.
The abovementioned has been valid for a long time and it represents a certain cycle within the energy sector. Understandably, the development results in various innovations within this cycle from both the technological and the partnership point of view. Technological innovations focus on effectiveness of the energy production, emissions and safety. The innovations in terms of business partnerships represent the changes in the structure of energy producers and their varying scopes of involvement in the energy production.

IEI entered the energy market in 1992. Since its establishment IEI has been building its position on the energy markets and it is constantly in a process of reinforcing its position of an important element in worldwide energy business. IEI has become a confident supplier of new power producing units designed for conversion of fossil fuels to electric and thermal energy. Creativity and independence have always been IEI`s unique attributes representing a strong foundation based on principles of creating and developing its own know-how. Within its activities on the energy markets IEI focuses on the latest technologies from the field of fossil fuels utilization. In addition, IEI strives to provide complex and tailor-made services to its customers on turnkey basis. IEI is not limited by territory, size or types of the energy source. The ability to cooperate with diverse types of investors, banks and business partners producing or procuring energy equipment is another significant feature of the company.

IEI is a creative and dynamic company built on solid foundations of creative potential and a number of self-built reference projects. Above all, it is a company with ambitions to grow further in terms of volume, territories and partnership position and especially in terms of quality of provided services.

The most valuable asset of IEI is its employees and their professional, proactive and friendly approach to its clients. Actually IEI employ more than 600 engineers, managers, administrators, and trade specialists. IEI is a member of many respected organizations and its work is inspected and supervised by renowned international certification institutions. Certified Quality Management System, Workplace health and safety, and environmentally friendly approach to all its activities are part of its corporate philosophy. The works of IEI are controlled by internal procedures and bylaws, which are compatible with "Integrated Management System. Today, IEI continues to be a reliable partner for any project, whatever the size and place.

NOTE
The Main Contractor/Supplier shall provide a Performance Bond (BP) of 2% (Two percent) maximum pursuant to the ICC Publication No. 458 INCOTERMS 2010 for EPCI (Engineering Procurement Construction and Installation) Agreement. This PB shall cover a period of Two (2) years guaranteeing the Contractor's performance, the quality, and operation of delivered technologies or implemented part of the project.

As the Main Contractor, IEI is responsible for:

8. Power Plant construction;
9. Power Plant technologies and equipment supply or procurement;
10. Installation;
11. Test;
12. Commissioning; and
13. Quality Warrantee of the Power Plant for a period of 24 months.

17.3 FINANCIAL GROUP OF THE PROJECT

17.3.1 EXIMBANK SR

The Export-Import bank of the Slovak Republic (EXIMBANK SR) was established under Act No. 80/1997 Coll. on the Export-Import bank Slovak Republic, amended by Act No. 336/1998 Coll., Act No. 214/2000 Coll., Act No. 623/2004 Coll. and Act No. 688/2006 Coll. and started its activities on 22 July 1997. The founder of EXIMBANKA SR is the state.

The main objective of the institution is to support the maximum export volume of sophisticated production to the numerous countries, while ensuring the return on investment through the minimization of the risks arising from insurance, credit, guarantee, and financial activities. EXIMBANKA SR assist both large and small (SME) companies and is prepared to provide solutions tailored to companies' specific needs. It is the only institution in the Slovak Republic authorized to provide export financing and pure cover backed by the government.

The EXIMBANKA SR mission is to provide state support for exports through the provision and financing of export credits and other services connected with exporting.

EXIMBANKA SR thus supplements the services offered by the domestic banking system by financing export operations that require long-term financing at interest rates and in volumes that are not available to exporters on the banking market under the current domestic conditions. This allows Slovak Exporters to compete on international markets under conditions comparable to those enjoyed by their main foreign competitors.

The recipient of supported financing may be an exporter (i.e. a legal entity with registered offices in the Slovak Republic, or in exceptional cases a natural person with permanent residency in the Slovak Republic), or their foreign customer. A manufacturer producing for export or a Slovak subject investing abroad may also receive some types of credits. The exporter's domestic bank or the importer's foreign bank may also be involved in these transactions. All EXIMBANKA SR activities are fully compliant with World Trade Organization (WTO) rules, the applicable recommendations of the Organization for Economic Co-operation and Development (OECD) and European Union directives.

17.3.2 EXPORT GUARANTEE AND INSURANCE CORPORATION, A.S.

EGAP, a.s. is a credit insurance corporation, insuring credit connected with exports of goods and services from the Slovak Republic against political and commercial risks uninsurable by commercial insurance.

From the point of view of business parties the political risks are of a force majeure nature. They include for example administration or legislative measures in the country of the borrower that prevent it from payment, or even political events in the country of the debtor in the form of revolution, war, general strikes, etc. Commercial risks are connected directly with the borrower and take a form of insolvency or denial of payment of claims.

EGAP insures in particular bank loans due in over 2 years, intended to finance export of energy, machinery and technological systems, investment projects, transport constructions and investments, usually to countries where political, economic and legal environment increases the risk of default.

It complements the range of commercial credit insurance products and fills the gap on the market and acts as a standard export credit insurance company in the role of a government tool to promote exports. The corporation provides insurance services to all exporters of Slovak goods, services and investments, irrespective of their size, legal form and volume of insured exports.

EGAP was founded in 1992 as a joint stock company fully owned by the state. The Czech Republic exercises its shareholder rights through the Czech Ministry of Finance, the Czech Ministry of Industry and Trade, the Czech Ministry of Foreign Affairs and the Czech Ministry of Agriculture. Its activities are governed by the Insurance Law and the Act No. 58/1995 Coll., on insuring and financing state supported export.

Short-term commercial insurance against risks of non-payment resulting from insolvency or protracted default of a foreign or domestic buyer is offered by *KUPEG úvěrová Pojišťovna, a.s.* co-owned by EGAP and the Belgian credit insurance company Ducroire – Delcredere SA. N.V.

17.4 OPERATIONS MANAGEMENT OF THE PROJECT

17.4.1 iSTROENERGO INTERNATIONAL, A.S. (LEAD OPERATOR)

ISTROENERGO INTERNATIONAL, A.S. (IEI), hereinafter referred to as the EPC Contractor of the whole project, is ready, willing, and able to undertake the Operations management and Training Agreement for a period of at least 5 years from effective date of commissioning the Plant. In order to effectively carry out the operations management and maintenance of the Power Plant and efficiently train the local staff, IEI shall cooperate with EUROMADE ENGINEERING & CONSTRUCTION LIMITED (EUMEC), MDA CAPITAL INVEST, A.S. (MDACI) and the Project Company, XENERGI LIMITED,

17.4.2 EUROMADE ENGINEERNG AND CONSTRUCTION LIMITED

EUROMADE ENGINEERNG AND CONSTRUCTION LIMITED (EUMEC) is engaged under contract by the IEI (Lead Operator) to assure the Operations Management of Project on its behalf and in cooperation with XENERGI LTD, MDA CAPITAL IVEST, A.S. and EUMEC. EUMEC shall monitor the management of the power plant and the training the XENERGI's staff for a period of 5 years maximum *i.e*. till full payment of loan provided by EXIMBANKA SR.

Operations management focuses on the delicate management of internal business processes to produce and distribute products and services. Many companies, especially those smaller in size typically don't mention "operations management", but they still carry out activities classified as "operations management". Some of these activities which are covered by operations management include product creation, development, production and distribution; although, operations management is in regard to all operations within a firm. Besides, EUMEC's operations management responsibilities shall include managing purchases, inventory control, quality control, logistics and evaluations.

The main purpose of focusing on the operations management is to accurately assess the efficiency and effectiveness of the company's processes. Therefore, EUMEC's tasks shall also include substantial measurement and analysis of internal processes.

The other participants, XENERGI and MDACI shall also assist IEI.

17.4.3 XENERGI LIMITED / XENERGI CONSORTIUM (Project Company)

As the Project owner, future manager of the power plant and actively engaged in the business of exploration and oil fields development services, XENERGI LTD shall appoint the fuel handling manager (quality monitoring, fuel supply and payment, etc.). The Fuel Handling Manager shall report to the Financial and Controlling Director and the Technical Director who shall be appointed by IEI (Operations Management Company)

XENERGI LTD shall also appoint the Financial and Controlling Director, who shall be responsible for financial management of the project, including the coordination and monitoring the project daily expenses, the loan payment to EXIMBANKA SR. The Financial and Controlling Director shall also report to IEI and MDACI (Operations Management Company).

17.4.4 MDA CAPITAL INVEST, A.S. / CONSORTIUM (Project Developer)

During the operation and management of the project, MDA CAPITAL INVEST, A.S. (MDACI) shall be responsible for the coordinating the tasks of all the entities participating in the management and operation of the power plant and their needs required to carry out sustainably their responsibilities. For this purpose, MDACI shall appoint the plant Operations Manager who shall report to the all the Directors of each department of the power plant, including the Managing Director (appointed by XENERGI LIMITED).

MDACI shall also be responsible for the internal auditing Company. The Internal Auditing Manager who shall appointed by MDACI shall be responsible for managing the execution of a comprehensive internal audit program. This includes conducting audits in a manner in which all relevant risks are assessed through substantive and control-based testing in an efficient manner to determine completeness, accuracy, validity and restricted access and/or effectiveness of the control environment.

The Internal Audit department shall be dedicated to providing independent, objective assurance designed to add value and improve enterprise-wide operations and support compliance. Internal Audit helps the power plant to accomplish its objectives by bringing a systematic, disciplined approach to evaluating and improving the effectiveness of risk management, control and governance processes by providing insight and recommendations based on analyses and assessments of data and business process. The scope of internal audit efforts is broad, and includes the efficiency of operations, the reliability of financial reporting, deterring and investigating fraud, safeguarding assets, and compliance with laws and regulations, including but not limited to testing in support of Model Audit Rule compliance.

17.5 HUMAN RESOURCES

17.5.1 GRAFTON RECRUITMENT INTERNATIONAL

GRAFTON RECRUITMENT is a Company that is driven by instinct and inspired by innovation. As a leading provider of Recruitment, Talent Management and HR solutions and with more than 30 years of experience, GRAFTON is one of Europe's largest independent HR Companies, with 30 offices in 7 countries.

At the beginning of its business activities, the company's core values were established on tremendous amounts of soul searching and discussion. Despite the lively debate, Grafton staffs are all united on one front: the Company business should be an ethical business, with ethics hard wired into unified culture and good conduct

Grafton, endeavours to lay emphasis community development; promoting and enhancing the future of communities. So their responsibilities go further than just keeping systems running and creating a positive social environment.

Now more than ever, transparency, accountability, trust and reliability are essential qualities for Grafton.

Partnership

Grafton Recruitment develops valuable and collaborative relationships between various partners, businesses and states organizations, with the goal to work together to achieve a common purpose, such as poverty reduction, education and community development locally, nationally and internationally.

- American Chamber of Commerce in the Czech Republic;
- British Chamber of Commerce in the Czech Republic;
- Deutsch –Tschechische Industrie – und Handelskammer;
- Slovensko-Česká obchodní komora;
- APPS;
- Czech Irish Business and Cultural Association;
- People Management Forum; and
- Klub personalistů kraje Vysočina.

NOTE
For this purpose, MDACI has already engaged GRAFTON, A.S. under agreement, a Czech Human Resources (HR) services Company for the selection of the Czech expatriates that will be in charge of the O&M of the Project.

17.6 CONSULTING SERVICES REQUIREMENTS

17.6.1 General requirements and responsibilities

The Consulting Companies shall be qualified to handle Civil Engineering Project Management, Technical Consulting, Energy Contracting, and Placement Order (Turn-Key), Technical Planning and Project Management issues for privates, industrial and public contractors and developers. The Consulting Companies shall also develop also customer-specific system solutions appropriate of the challenge of today's open market.

During development, The Developer will lay emphasis on Consulting Companies that considers it a high priority to provide professional services through guidance during both planning and the realization phases. The Consulting Companies shall handle specific tasks in co-operation with experts in the legal, economic and technical fields of the foreign and local companies.

The Consulting Companies shall also initiate competition to the most cost-effective supply of energy and water facilities.

The Consulting Companies shall also be able to negotiate optimal supply contract for energy facilities for the Clients through the use of competitive procedures. They should be able to obtain reasonably priced, safe and environmentally friendly energy supply conditions. Legal questions which arise during this procedure are answered by a qualified lawyer specialized in the field of commercial laws.

The Consulting Companies shall assist the Client throughout the entire procedure saving as consultant and technical planner. They should be able to develop solutions for the development and implementation and operation for the whole project systems (equipment, technologies, construction materials, fuel, water, electricity, etc.). These solutions can be opened to the market in a competitive procedure.

Their experts should also be planners in the area of Estates, Transportation systems, Logistics, electric energy generation plants, Transmission and distribution networks and application. Their areas of expertise should not be limited to long-distance heating network and interconnecting stations, cooling generation and distributions, gas network, electricity networks, heating and power coupling systems, power plant and technical equipment systems.

The Consulting Companies shall be able to create integrated energy, water and technology concepts and effectively realize them in the planning and construction phases. In the process, consultants will always take care to balance the sometimes conflicting aims of low investments levels and minimal operation expenses. The selective consulting teams will inform the Developer regarding up-to-date economic and technical innovation and select appropriate application strategies.

17.6.2 Pre-qualification requirements

Interested reputable consultancy services providers must have necessary competence and submit the following documents:

1) Certificate of Registration/Incorporation;

2) Company's Current Tax Clearance Certificate issued by the proper authority;

3) VAT Registration Certificate;

4) Tax Payers Identification Number (TIN);

5) Evidence from the Company's Bankers as to its financial capacity to undertake the project if awarded. The Prospective Consultancy Services Providers shall be required to demonstrate that they are financially capable to provide the services.

6) Company Profile: evidence of past performance (5 latest years), Curriculum Vitae of the Consulting Company's key staff or experts with passport photo; list of Materials (working tools, machines and equipment);

18 SOURCE OF FINANCING AND FINANCIAL MODELS

The primary financial model of the Project is Export Credit (*i.e.* Buyer's Credit), which shall be arranged by MDACI/MDACI Financial Consortium for the Engineering, Procurement, Construction and Operation management (EPCM) by ISTROENERGO INTERNATIONAL, A.S. (IEI). There are many other financial models for project EPC or Project Construction Implementation, as provided below.

18.1 TYPES OF EPC OR CONSTRUCTION IMPLEMENTATION FINANCES

There are many types of financing products available in the market, which are tailored towards the purpose of energy implementation project. For instance, financing can be used for site acquisition and/or carries pre-development risks, bridging purposes, construction activity and for fixed term investments. Accordingly, each of these carries with it different types of risks. For instance, financing for site acquisition and/or carries pre-development risks (which include planning, regulatory approvals); bridging finance carries funding risks (such as movements in interest rates); construction finance carries implementation risks (such as cost blow-outs, project delays, industrial relations, and expected rental income); and term investments carry market risks (which include changing space market fundamentals, leasing conditions and asset pricing (on completion). In all, when assessing risk, consideration needs to be given to the nature and purpose of the project, the type of security available, the credit status of the recipient, and forecasting analysis to assess payment prospects. Many debt financing arrangements consider some of the following key elements in structuring such packages. These elements include: debt service or Interest Cover Ratio (ICR); the form of security (such as mortgage, cash deposit or guarantees); the Loan-to-Value Ratio (LVR) or gearing level; and the return on capital. This information is used by the financier to assess five key issues: i) cash flow sustainability in terms of the quality of income stream, lease covenant or term; ii) the quality of the security (or collateral); iii) the quality or credit-rating of the borrower; iv) conditions of the energy market; and v) the refinance risk.

In our case, the site acquisition and/or carries pre-development risks are not included in the realization of the aforementioned Project. The CBN Power Project financial scheme is design to cover the Project Construction (quality) and Management (efficiency) risks.

18.1.1 Local financial supports providers

In the national and international market, there are many providers of equity and debt funding. Providers of equity funding include: private investors, partnerships/syndicates, unlisted ownership vehicles, World Bank, Millennium Development Goals (MDGs), Community Development Lenders, Certified Community Development Financial Institutes, Specialized Loan Funds, Small Deal funds, NGOs, etc. Debt funding mainly comes from banks. This loan or equity contribution shall be raised via Guaranty Trust Bank Plc. (GTB). The Project Company, XENERGI and/or its Consortium, may also use its own equity contribution or other financial institutions, which provide debt finance include: finance companies, building societies, insurance companies and investment banks.

18.1.2 Foreign financial supports providers

As the Project is satisfactorily demonstrated bankable and financeable, any of the MDACI Financers is always ready, willing and able to provide a financial support up to **85% of the Total Investment Capital (TIC)** at a **fixed interest rate** of **5% per annum** (or floating interest rate), which shall be reimbursable within a period of 5 years from effective date commercial operation of the 10.2MWh IGCC Power Plant.

18.2 EXPORT CREDIT

It is always required by the Financier, the EXIMBANKA SR or any EU prime bank that the Project Owner, XENERGI LIMITED, shall provide the following documents. These documents constitute the major (98%) scope of works of the Project development, which shall be borne by the Project owner at his own cost.

a) Letter of Interest (LOI) from borrower seeking financing (*addressed to MDACI*);

b) Audited financial statements of the borrower for the last 3 years (management accounts in lieu of audited accounts for the current years);

c) A business plan or technoeconomic feasibility study for the underlying project, including the cash flow projections, underlying assumptions and repayment schedule;

d) Source of primary fuel from XENERGI LTD and/or Project own Coal mines.

e) Power Purchase Agreement (PPA) to be signed between XENERGI LTD the potential off-takers registered as a Free Zone Enterprise (FZE) in the EFTZ;

f) Details of Design and Build Contractor Engagement (i.e. EPC Agreement);

g) Details of Operation and Maintenance Contractor engagement;

h) Details of any Consultant/Adviser engagement;

i) The Project's financial model;

j) Certificate of Incorporations of the Project Company;

k) Environmental Impact Assessment (EIA) report approved by the Federal Ministry of Environment (FMENV) or the relevant Nigerian Authority;

l) VAT Registration Certificate;

m) A sworn statement that the company is not in receivership or about to be in receivership;

n) A sworn Affidavit that the company is not a replacement for a hitherto tax defaulting company;

18.2.1 Financial Support Scheme by an MDAC's Financier for OECD Countries

As in any our prime commercial / export banks, most of the sources of funding are organized through the following financial tools called **Buyer's Credit** or **Seller's Credits**. Buyer Credit is mostly used for better transparency in the funding procedure of technology and service provided by an Exporter or a Local Supplier. Seller credit can be useful when buyer is short of the cash required to make for the signature of the EPCI Agreement

between the Contractor (Exporter or Local Contractor/Supplier) and the Project Owner (XENERGI).

For the purpose of this analysis, MDACI propose to use the case of BUYER CREDIT SCHEME, which is the most efficient financial tool for the development and implementation of such project with such magnitude. In this FINANCIAL SCHEME, the Buyer (Project Owner) and the Supplier (Technical Partner) shall enter a Technical Partnership Agreement (TPA). The basic term and conditions of this TPA satisfactory to the Financiers (commercial / export bank and export guaranty and insurance corporation) for the reimbursement of the loan are as follows:

- Technical Partner and EPC Company, IEI shall be engaged under a Training and Operations Management operation of the power plant till full reimbursement of the loan provided by any of the MDACI's Financial members;

- MDACI Consortium composed of MDA CAPITAL INVEST, A.S. (Czech Investment Company), EUROMADE ENGINEERING & CONSTRUCTION LTD (Nigeria Power and Energy Company and subsidiary of MDACI) shall be responsible for:

  - coordinating the Project between the stakeholders;

  - troubleshooting and planning independently the improvement of the project quality and economy with IEI; and

  - following-up and controlling independently in cooperation with the Project Company (XENERGI LTD) payment collection and deposit directly to the Project Account in GTB PLC, the local receiving bank and guarantor of the payment back of the loan on a monthly or yearly basis to MDACI financing bank.

Buyer's export credit

A Buyer's credit is based on a separate loan agreement between the exporter's bank and the buyer (or buyer's bank).

It enables realization of more complex and large-scale Slovak deliverers to foreign importers.

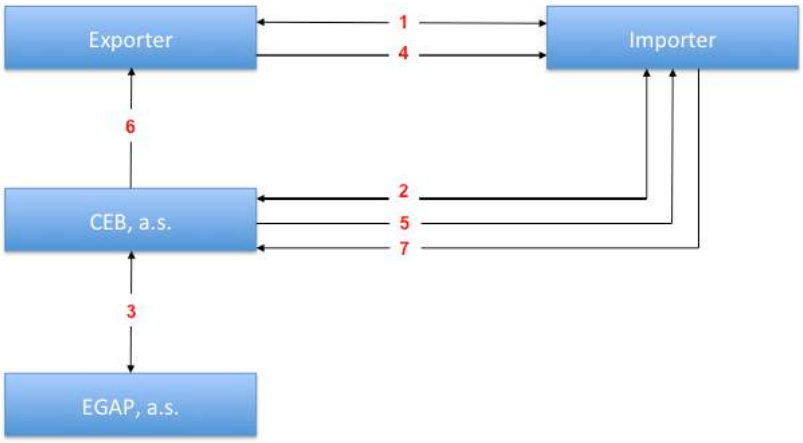

Fig. 23 – Buyer's export credit scheme.

1) Export contract for the delivery of goods and/or services;
2) Credit agreement;
3) Insurance policy covering credit risks;
4) Delivery of goods and/or services;
5) Buyer's Credit;
6) Credit disbursement in favour of the exporter; and
7) Credit repayment

How does it work?

The primary features of the Supplier Export Credit (SEC) are:

- The exporter grants a loan to the buyer and sells its claim to the bank for refinancing purposes.
- The Foreign Exporter (FE) contracts with their international buyer to supply goods and/or services;
- A separate and parallel Loan Agreement is entered into between a Lending Bank and the Exporter or their Bank, in order to finance the exporter's supply of goods or services on credit terms;
- The Lending Bank (LB) receives a Bank Guarantee (BG), which covers the risk of default on repayment, as security to provide this loan.
- The LB advances the funds to the Exporter in line with the terms of the Export Supply Contract, which typically results in the Exporter being paid in full by the time the goods have been shipped or the project has been completed;
- The Buyer's Bank makes loan repayments to the Exporter's Bank in accordance with the agreed repayment schedule, which is normally 5-10 years maximum, equal instalments of principal and interest.

What are the benefits?

Like the other products, Buyer Credits (BC) can provide an exporter with a competitive advantage of being able to grant a term of credit to its Buyer, whilst receiving up-front cash payment for its exports in accordance with their standard supply contract. However, the key benefit of a BC is that the Loan Agreement is separate from the EPC Agreement (Supply Agreement) and is not subject to Supply Contract disputes.

When should it be used?

Loan Agreements require extensive and lengthy legal negotiation. Due to the costs involved with drawing up a separate Loan Agreement, a BC is most useful for export transactions of € 10 million (Ten Million Euro) and above.

We recommend that an Exporter and Buyer contact their respective Banks as soon as a potential deal is anticipated and provides as much of the information available on the deal and buyer as possible.

Advantages for the exporter and the importer respectively in general

- A credit transaction becomes a cash transaction;
- Attractive interest rates (Euro, SERV-cover or US$);
- SERV enables financing in countries where other possibilities are limited;
- Full or partial discharge of the exporter from the risks;
- No collection and "reminder" work for the exporter; and
- Improvement of liquidity;

18.2.2 Regulations of combating bribery in international trade

Requirements related to project entities & EXIMBANKA SR's obligations

Pursuant to the OECD documents above, exporters (or applicants for state supported financing) must, among other things.

- Declare that they are aware of the provisions of the OECD Convention on Combating Bribery of Foreign Public Officials in International Trade, and agree to take all measures necessary to comply with them;
- Demonstrate that they have developed and apply management control systems that combat bribery in accordance with the Export legal system;
- Declare that neither they nor anyone acting on their behalf such as agents have been or will engage in bribery in the transaction in question;
- Declare that neither they nor anyone acting on their behalf in connection with the transaction are currently under charge, or have been convicted within a five-year period prior to the application, or have been subject to equivalent administrative measures for violation of laws against bribery of foreign public officials of any country;
- Upon demand disclose the identity of persons acting on their behalf in connection with the transaction and the amount and purpose of commissions and fees paid, or

agreed to be paid, to such persons.

The OECD documents oblige Financing Bank

- To verify and ascertain whether exporters or applicants are listed on the publicly available debarment lists of the international financial institutions (in particular of the World Bank group);

- To undertake enhanced due diligence if (i) the exporters or applicants appear on the publicly available debarment lists or (ii) the bank becomes aware that the exporters or applicants or anyone acting on their behalf in connection with the transaction is currently under charge, have been convicted within a five-year period prior to the application, or have been subject to equivalent administrative measures for violation of laws against bribery of foreign public officials of any country or (iii) there is reason to believe that bribery may be involved in the transaction;

- To inform the law enforcement authorities promptly if there is credible evidence of bribery at any time in connection with the award or execution of the export contract;

- To suspend approval procedure of the application during the due diligence process if, before credit or other support has been approved, there is credible evidence that bribery was involved in the award or execution of the export contract, and to refuse to approve credit or other support if the enhanced due diligence concludes that bribery was involved in the transaction;

- To take appropriate action such as denial of payment or refund of sums provided in the event bribery has been proven after credit or other support has been approved.

18.3 PROJECT EXPORT CREDIT GUARANTEE OR INSURANCE

18.3.1 Insurance of a medium and long-term export buyer's credit

An export buyer credit is a credit extended by a bank to a foreign importer for purchase of goods or services. The bank pays the exporter and the owed amount is then repaid by the foreign importer on a regular schedule stipulated in the credit contract. The recipient of the credit and afterwards the debtor is in some cases the bank of the foreign importer. The maturity of the credit exceeds 2 years. **Conditions of insurance are governed by the OECD Arrangement**; these rules require a down-payment by the foreign importer of at least of 15 per cent before the credit is extended. EGAP also reserves the right to request from an exporter to submit an environmental impact assessment of the export in the importer's country. The insured is the bank that is covered against the risk of the non-repayment of the extended export buyer credit on the stipulated schedule.

An insurance loss is a partial or full non-repayment of the insured credit from commercial or political reasons or their combination. Commercial reasons are general inability of an importer to pay for own due obligations (insolvency) or refusal of the payment without any legal reason (protracted default). Among political reasons belong *e.g.* administrative decisions or legislative measures of the importer's country preventing the importer from payment, or restrictions in conversion of payments as a result of political occurrences in

the country of the importer as well as other events in the country of the importer as war, revolution, civil disorders and natural catastrophes.

The amount of insurance premium depends on the volume of export, negotiated payment conditions, on way how payments are secured, assessment of character and risk level of the importer, assessment of risk level of country or territories related to performance of the export contract and on the amount of the self-retention. The negotiated amount of the insurance premium already includes possible increase or decrease of the insurance risk and is unchangeable during the whole duration of insurance.

18.3.2 Insurance of a Credit for the Financing of Investments

All calculations made are not binding. Final premium rates are only indicative. It covers the corporate risk only as well as those business transactions where no credit has been extended for insurance premium and down payment. The coverage policy as well as the exact premium will depend on individual terms stated in a Credit Insurance Proposal Form

- **Input Date**
  - **Country** – Nigeria (country of category 5);
  - **Total Investment Capital.**

Table 27: Financial assumption – tabulated financial information

S/N	Item	Value
1	Investment Capital (CI) [EUR]	
2	Equity Contribution (15% Cash of CI) [EUR]	
3	Interest Rate [%]	5
4	Credit – principal [EUR]	
5	Grace Period [yr.]	2
6	Repayment Period [yr.]	5

NOTE 1:
The Total investment Capital does not include the followings:
- *Including Project O&M for a period of 3 months;*
- *Delivery Cost to construction site;*
- *Port charges; and*
- *Installation and commission fees.*

NOTE 2:
This investment conditions are negotiable based on the followings concluded assumptions defined in the Project techno-economic studies.
- *Grace period (Months);*
- *Payment back/loan reimbursement period (Months); and*
- *Guaranteed Power Purchase Agreement (PPA)*

18.3.3 General insurance conditions against the risk of non-payment

These General Insurance Conditions are effective from 4 September 2009 as provided in the Project Administration Manual (PAM).

Rules for origin of goods

The share of goods and services from the export country in the total value of the export as one of basic conditions of insurance with state support has to reach at least 51 %. An exception in the form of a lower share is possible only in transactions when the exporter unequivocally evidences that goods necessary for completion of the export are not produced in the export country.

Decisive for determination of the **country of origin of goods** is that the exporter invoicing these deliveries to a foreign buyer is a company registered in the **export country** or its foreign subsidiary. Similarly, sub deliveries purchased by the exporter from other production companies of the **export country** are considered as deliveries of **country of origin**. Requirement of the **country of origin of the goods and services** is fulfilled also in case of sub deliveries, which the exporter and/or its sub supplier from the same export country has purchased abroad but their value has been further increased in production for export. Only such sub deliveries purchased by an exporter abroad and subsequently resold to a buyer are considered as goods and services of foreign origin for the determination of the required **export share**.

From the calculation of the share of the **export country** are excluded entirely:

- foreign sub deliveries for which the Export Guaranty and Insurance Corporation gained reinsurance;
- foreign sub deliveries financed without the state support of the export country； and
- foreign sub deliveries covered by counter guarantees.

18.3.4 Environmental Impact Assessment of an export and investment credit

Principle of sustainable development requires reduction of negative impact of human economic activities on environment. Review of environmental effects of the export and investment has been a standard procedure in a majority of developed countries and it is one of basic conditions for the financing of export projects for institutions from the World Bank Group, development agencies and regional development banks.

The OECD Recommendation on Common Approaches on Environment and Officially Supported export credits came into force on **January 1, 2004**. It contained an undertaking of all member countries not to support through their institutions those projects, which harm environment. The OECD Council approved the revised Recommendation in **June 2007** coming into force on **September 1, 2007**.

All the procedures of the **Export Guaranty and Insurance Corporation** are always in compliance with the effective international rules in the area of environment protection, including the revised Recommendation of the OECD Council. Review of environmental impact in the county of final destination is one of basic conditions in insurance of export and investment; an expert opinion has to be prepared for project where a significant negative environmental impact can be foreseen. **The Export Guaranty and Insurance**

Corporation always acts in a way not prolonging inadequately the appraisal of an application for insurance and not burdening clients with out-off proportion expenses.

Environmental review shall be made for all projects where the Exporter applied for insurance of a credit with state support with maturity exceeding 2 years as well as for all investment in foreign countries. Responsibility for environment compatibility of the project rests always with the main supplier. As long as the exporter is in position of a subcontractor, the submission of a review prepared **for the main supplier is sufficient**.

The insured has an obligation to inform public in cooperation with the **Export Guaranty and Insurance Corporation** on impact of the export on environment while respecting trade secrets, intellectual and industrial property and know-how.

Procedures in reviewing environmental impact of export and investment in country of final destination

A positive assessment of environmental acceptability of the export and investment in the country of final destination is one of basic preconditions for conclusion of an insurance contract. Environmental review shall be made for all projects where the Exporter applied for insurance of a credit with state support with maturity exceeding 2 years as well as for all investment in foreign countries (hereinafter the "export").

Process of assessment of environmental impact of the export in the country of final destination is starting with submission of a filled-in Questionnaire for environmental review of the export project. The Questionnaire is to be filled-in by the Exporter also in case insurance is requested by a bank extending, e.g. a buyer credit for the financing of the export. **It is indispensable that the Exporter submits the filled-in Questionnaire as soon as possible, i.e. during start of negotiations on financing and insurance of the export.** Based on this Questionnaire, the **Export Guaranty and Insurance Corporation** shall classify the export into one of 3 below described categories and shall decide whether it is necessary or not to prepare an expert opinion on the environmental impact.

In other cases, the Exporter shall submit the Questionnaire including the statutory declaration directly to the **Export Guaranty and Insurance Corporation** together with application for insurance and the **Export Guaranty and Insurance Corporation** may refrain from requirement for further reviewing of the environmental impact of the export.
Environmental classification of the project

Pursuant to the rules and regulations established by the Nigerian Electricity Regulatory Commission (NERC), a new electricity power project shall have an approved Environmental Impact Assessment (EIA) by the Federal Ministry of Environment (FMENV). The EIA shall be based on the international, world bank and local environmental rules and regulations. These environmental impacts go beyond an area where the said export will be realized, consisting primarily of exports to **sensitive areas or sectors.**

Procedure for assessing the environmental impact of an export transaction

During the assessment of the Project's EIA, MDACI's experts shall ensure that all the following environmental impacts are clarified:

What is the purpose of placing export transactions in categories?

Placing export transactions in categories allows decisions to be made regarding subsequent environmental review.

Since the project is already classified into **category A**, MDACI/MDACI Consortium must submit to **the financier or financing bank** a recognized and approved Environmental Impact Assessment (EIA) by the federal and state environmental authorities of Nigeria. A condition for the provision of export financing is the submission of an assessment and compliance of the project's parameters with it.

Assessments are carried out at the cost of the exporter, always by a person authorized for this purpose by the Ministry of the Environment of the **export country** and according to international rules (the World Bank Pollution Prevention and Abatement Handbook). The **financing bank** will provide the Applicant with a list of authorized persons, including their contacts.

In the case of **category B**, the assessment will not include all the information about the environmental impacts of the project required for **category A**, but only information on the extent of the potential specific adverse environmental impacts of the export. The actual content and scope of the assessment for a project placed in category B is stipulated by the authorized person taking into account the international rules.

When preparing the assessment, the authorized person will take account of the state of the environment at the export's final destination at the time the application for export financing is submitted, will assess the environmental impacts relating to the preparation, implementation and operation of the selected export as well as its termination, and will assess the regular operation and the possibilities of accidents. The assessment must include the requisites stipulated by international rules.

What is a recognized assessment?

If the Exporter is not the main EPC contractor, for the purposes of assessing the environmental impacts of the respective project the submission of an already existing assessment prepared **abroad is sufficient**. The assessment can thus be substituted by a so-called "**recognized assessment**", which may be:

- An assessment in English prepared by an entity in the final destination country for the respective project according to that country's legislation, on condition that the assessment complies with international rules. The Applicant will ensure that the assessment complies with international rules via the authorized person;

- An assessment in English recognized by an international financial institution if the respective export transaction is part of a project financed by that institution;

- An assessment in English recognized by the export credit agency of an OECD country if the respective export transaction is part of a project for which this agency is providing insurance or financing.

Are there any possible exceptions from these rules?

Yes; although all export projects are subject to a primary assessment (questionnaire), the Common Approaches give **the financier / financing bank** a certain amount of freedom when making a decision about the processing of a detailed assessment, namely in cases when:

- The export financing is provided in connection with an export transaction that makes up less than 5% of the value of the whole project; in this case the **financier** may decide that the assessment will be prepared in accordance with the limits given in special legislation as provided in *Appendix 3* of the PAM.

- It is clear from the submitted documents that the value of the export transaction does not exceed € ***10,000,000*** and it is also clear that the project will not have a significant adverse environmental impacts; in such a case **the financier** may decide to release the respective export transaction from the requirement for a detailed Environmental Impact Assessment.

The Financier will inform the Applicant of its decision regarding an exception in writing without delay.

Will somebody monitor compliance with the environmental requirements stipulated in the assessment?

During the entire life of a credit, **the financier** is entitled to require the exporter to provide written monitoring reports that include the requisites stipulated in the assessment. The reason for such a request may be any information or suspicion that during the execution of the project there has been environmental damage. The obligation of the exporter to comply with the conditions in the assessment will be one of the conditions for the provision of the export financing.

The Applicant will submit the monitoring reports to **the financier**; the exporter will ensure their preparation by an authorized person at its own cost.

What will happen if an export does not comply with the parameters stipulated in the assessment?

If a monitoring report demonstrates serious non-compliance with the conditions of an assessment by the exporter, **the financier** will be entitled to suspend financing until the situation is brought into compliance with the assessment. **The financier** will inform the Applicant in writing of the suspension of financing and the conditions for its renewal.

The financier will renew financing only on the basis of a new monitoring report submitted by the Applicant that demonstrates that the conditions of the assessment stipulated for the environmental impacts of the respective export transaction have been fulfilled.