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Electricity Stability in Nigeria Through Increased Hydro Power Generation

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***Abstract*---- Slow response to generation and delivery of stable electricity in Nigeria, poses as a problem to development of the country. Industries and residential homes in the country now use generating set as an alternative due to instability in electricity supply. To reduce problem of power outages in Nigeria through renewable sources of energy, hydro power stands as one option to meet the growing demand of electricity because of presence of many rivers with hydro potentials.**

***Keywords*----Electricity, Hydropower, Power outage, Renewable**

I. INTRODUCTION

Energy sources are usually classified into two main groups – renewable energy and non-renewable energy sources. Renewable energy sources available include biomass, geothermal energy, hydropower, solar energy and wind energy. This report focuses on hydropower for electricity generation.

Hydroelectricity or hydropower is a domestic, reliable and emission-free energy resource that is renewable through hydrological cycle and harnesses natural energy of flowing water to provide clean, fast, flexible generation of electricity [1]. In hydroelectricity generation, the potential energy (gravitational energy) of water in motion from the dam is first converted into mechanical energy and finally converted to electrical energy.

Present-day hydroelectric plant is the end product of 2000 years of technological advancement, from the creaking wooden wheel, converting a few percent of water power into useful mechanical output, to the modern turbo-generator spinning at 1500 rpm and producing electric power at efficiency which can reach 90% [2]. Hydro power in 2005, supplied an estimated 715,000MW, approximately 19% of the world's electricity and accounted for over 63% of the electricity harnessed from renewable sources [3]. Globally, the role of renewable energy sources especially hydro power is expected to become increasingly important in the future.

Worldwide average growth rate of hydroelectricity generation in the future are estimated from about 2.4% [4] to 3.6% [5] per year between 1990 and 2010 or 2020 respectively. A large number of global hydro power development projects with a total capacity of about 100,000MW are currently going on. The greatest contribution is coming from Asia (84000MW). The contributions from other regions are: Africa (2403MW), South America (14800MW), Europe (2211MW), North & Central America (1236MW) [6]. To facilitate continuous energy (Electricity) supply globally through renewable energy sources, hydro power generation stands as one option to meet the growing demand of energy.

Nigeria has abundant water resources distributed over the country which can be harnessed. Nigerian's hydro potential is high and hydropower currently accounts for about 32% of the total installed commercial electric power capacity [7][8]. Generally, electricity with other basic infrastructure such as good roads and water supply are treated as essential service for the economic growth and development. The rivers (large and small) in the country, would contribute to the hydro potential of Nigeria when developed. The major rivers of Nigeria such as the Niger, Benue, Cross River and kano and their tributaries along with some smaller rivers, provide an enviable potential for the exploitation of hydro energy in Nigeria [8]. To ensure stable supply of electricity in Nigeria through hydro power, additional dams should be constructed at different rivers with hydro potentials to boost hydro power generation.

II. DYNAMICS BEHIND HYDRO POWER GENERATION

Hydro power is generated by the gravitational force of falling water. In most cases, a dam which stores lots of water behind it in the reservoir [9] and also increases the head (height) of the falling water depending on the type of hydro power plant to be constructed. The hydro power generation is a function of the amount of head and flow available. The force of the falling water through the penstock drives the turbine mounted at the end penstock.

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Then the rotational hydro-mechanical energy generated by the turbine is converted to electrical energy by the generator.

III. Hydro Power Potentials In Nigeria

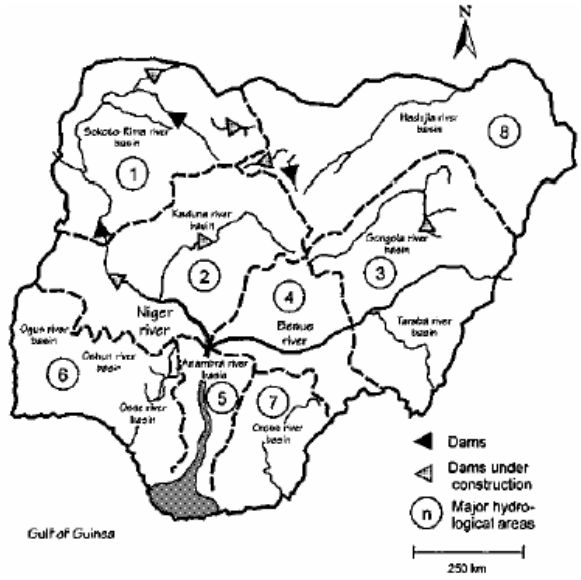

Fig I. Map of Nigeria showing major rivers and hydrological basins [17]

To achieve stability in electricity production through hydro power generation, a view of the rivers (small and large) and hydrological basin of Nigeria is necessary and important. From fig. 1 above, the map of Nigeria shows completed dams, uncompleted dams and major hydrological areas of the country. Also shown in the map are other rivers flowing within the country which would contribute to boosting the electricity generation through increased hydro power.

Nigeria has high hydro power exploitable sites but they are yet unutilized. Form the map, rivers (small and large) distributed all over in Nigeria contains high potential sites for development of hydro power scheme to meet the electricity supply demand of the urban and rural areas of the country. For many years, hydro power electricity supply in Nigeria has been through kanji dam, jebba dam and shiroro dam with capacities 760MW, 570MW and 600MW respectively. Utilizing the hydro power potentials of the rivers in Nigeria, will not only meet up the increasing energy demand of the country but accelerate the development of these areas in terms of social infrastructures.

It can be seen or observed from the map that small hydro power plants can be set up virtually in all parts of the country. Nigeria has 278 yet undeveloped sites for small hydro power production, with the total capacity of 734MW [8]

In utilizing the hydro power potentials of these Nigerian rivers, dams are to be built. For the effective utilization of hydro power potential sites from the map, some parameters are to be considered and they are as follows:

- Type of hydro power plant
- Hydro power output estimation
- Size of hydro power plant
- Hydro system components and application
- Method of resource storage
- Merits and demerits of hydro power.

A. Type Of Hydro Power Plant

The type of hydro power scheme depends largely on the purpose in which it will be used for. With respect to this, dams built could be used for many purposes such for electricity generation, water supply and irrigation.

TABLE I
TYPES OF HYDRO POWER PLANTS [1],[16

Type	Attributes
Impoundment	A dam is built across a river impounding a head of water behind it in a reservoir which can be released through a turbine to generate electricity.
Diversion	Sometimes called run-of-river, facility channels a portion of a river through a canal. It may not require the use of a dam and thus has a lower environmental impact.
Pumped Storage	When the demand of electricity is low, pumped storage facility stores energy by pumping water from lower reservoir to an upper reservoir. During periods of high electrical demand, the water is released back through a turbine to generate electricity.

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B. Hydro-Power Output Estimation

Knowledge and application of the following parameters will help in determining and achieving the desired power output for hydro-electricity generation:

The general formula for any hydro system power output is stated below:

$$P = \eta \times \rho \times g \times Q \times H$$

Where P = the mechanical power produced at the turbine shaft (KW), η = the hydraulic efficiency of turbine(% divided by 100), ρ = the density of water (kg/m^3), g = acceleration due to gravity (9.81 m/s^2), Q = the volume flow rate passing through the turbine(m^3/s), H = the effective pressure head of water (m). *Head is the distance between the water intake and the turbine. See fig.2 below.*

C. Size Of Hydro Power Plants

Hydro power plants are generally classified according to sizes of their generating capacity. Electricity generated from hydro power plant, does not only depend on it generating capacity (i.e. type of installed turbine and generator) but also the amount of available water. Hydro power plant sizes and their generating capacities are as follows:

TABLE II
HYDRO POWER PLANT SIZES [1]

Sizes	Capacity
Micro hydro power	Produces hydropower capacity of up to 100KW of electricity.
Small hydro power	Produces hydro power capacity of 100KW to 30MW of electricity.
Large hydro power	Produces hydro power capacity of more than 30MW of electricity.

D. Hydro System Components And Application

This section focuses on the components required for hydro power generation:

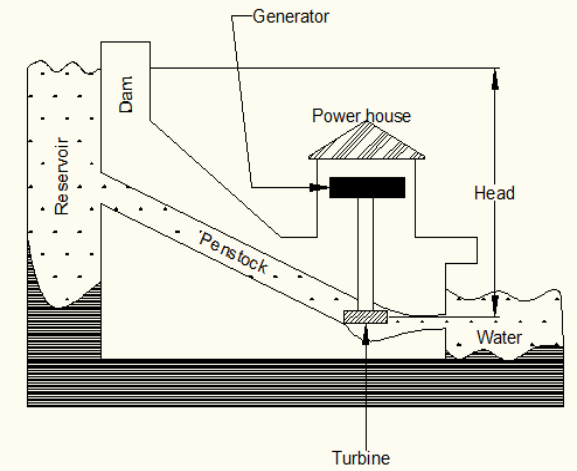

Fig II. Hydro power plant.

I) Penstock: This is described as the tunnel, channel, pipeline through which quantity of water (flow) for hydro power generation is passed or delivered to the turbine. It is constructed inside the dam it starts at the upstream side of the dam and ends in the down downstream through to the turbine positioned inside the powerhouse. The water pressure increases as it flows down through the penstock [10] to the turbine.

II) Turbine: This converts the force of the flowing water into the mechanical energy by the spinning the turbine as water flows in through the penstock. The flow spins the shaft by striking the blades of the turbine runners. Due to the pressure increase as water flows down the penstock [10], force is created on the blades of the turbine as the water is directed towards it. Energy of the flowing water is transferred to the shaft which runs from the turbine into the generator. The turbine transforms the energy of the flowing water into rotational energy [11].

Hydropower turbines are selected depending on factors such as head, the flow of water and site conditions. There are two types of turbine namely

1) Impulse turbine
2) Reaction turbines

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III) Impulse turbine: Mostly used for high heads and low flow hydropower systems. This type of turbine uses the velocity of the flow (water) to move the turbine when the stream of water hits the bucket on the runner. The flowing stream of water strikes the turbine runner and pushes it to move in a cyclic form. Impulse turbines are usually applicable in sites where the water source has high head (6.1m or more). It changes the velocity of the water jet and the resulting change in momentum cause a force on the turbine runner (blades). On striking the turbine blade, through a nozzle directed to it, the potential energy (pressure) is converted to kinetic energy. Impulse turbine does not require any housing or casing for its operation and there is no pressure change at the turbine blades. Pelton and turgo wheel are common types of impulse turbine, and are commonly used for high head micro hydro system.

IV) Reaction turbine: This type of turbine is mostly used for low heads with large flow of water. Reaction turbine uses the pressure of flow, to spin or move the runner for energy production. In its operation, both kinetic energy and potential energy of the water are converted into useful work by the reaction turbine, with all blades maintaining contact with the water [11] entering through the penstock. The reaction turbine is immersed in water and is driven by the difference in water pressure between the pressure side and the discharge side of the runner blade [14]. Reaction turbines are often used or applied for large scale hydro power generation. The Francis, propeller turbine and kinetic turbine [1] are kinds of reaction turbines mostly in use.

IV. Application Of Water Turbines

This table describes the use in low, medium and high head application of the different types of water turbine. This in combination with other factors will help to ascertain the best type of turbine to use for optimal productivity.

TABLE III [15]

	High head	**Medium head**	**Low head**
Impulse turbine	Pelton Turgo	Cross flow Multi jet pelton Turgo	Cross flow
Reaction turbine	--	Francis	Propeller Kaplan

V) Generator: The mechanical energy produced as the water flows through the turbine is converted into electrical energy by the generator. The shaft, exciter, rotor and the stator are the major components of the generator. The exciter of the generator sends an electrical current to the rotor when the flow of water through the penstock to turbine turns the shaft. The rotor comprises of series of large electromagnets that spins inside the stator, which is a tightly wound coil of copper wire [12] causing a magnetic field which result to production of alternating current due to electron movement. Alternating current produced by the generator, is converted to a higher voltage current by the transformer. Electricity generated is from the transformer via transmission cables to homes, schools, etc for consumption.

V. Method Of Resource Storage

Storage is provided in order that water may be available when required to meet the electrical system load [13]. Storage facilitates the provision and availability of water for hydro power generation considering a number of factors such as the geological, climatic, topographical, availability of skilled labor and materials. Provision of adequate storage, eases the operational and functional challenge of a hydro power scheme towards attaining the load requirements. Geological conditions and topography usually limit the amount of storage.

The installed plant capacity of any hydro power plant should be available when needed especially in dry weather so as to meet the load requirement. To ensure stability of power (electricity), considering the factors above, dam is constructed to ease the problem of inadequate flow.

Dam design takes into consideration certain forces [13]

- Fluid pressure and weight density of materials which are amenable to calculation
- Silt deposit, ice, earthquake, uplift pressure and effect of flood which depend largely on experience.

A. Merits Of Hydro Power

- Hydropower does not emit carbon dioxide [2] i.e. it is a clean energy source.
- Hydro power is a renewable source of energy.
- Dam which serve as reservoir could also be useful for other activities like fishing, irrigation.
- Constructed dam for hydro power contributes to generation of electricity for many years and at constant rate.

- Hydro power reduces dependency on traditional fossil fuel for electricity generation.
- Water can be stored for future generation of electricity.
- Maintenance of dam is less expensive once it has been constructed.

B. De-Merits Of Hydro Power

- Dam construction takes time and is expensive.
- Natural ecology of river, fishes and livelihood of people are been disrupted by construction of hydro power dams.
- Large dam construction causes serious geological damage.
- Hydro power requires large volume of flowing water and would reduce electricity production when there is decreased rainfall due to climatic change.

VI. Conclusion

Instability in the generation and supply of electricity (hydro) in Nigeria can be attributed to non-utilization of available exploitable sites. To effectively utilize these hydro potential sites in Nigeria for power generation, more dams are to be constructed. Electricity crisis in Nigeria has created an imbalance in the nation towards achieving effective management of industrial and other socio-economic development in the country.

Development of more hydro power scheme in Nigeria will drastically reduce unemployment, provide basic infrastructure to the rural areas, reduce poverty and meet the increasing demand in electricity supply.

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