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An overview of integrated power supply system: Solution to Nigeria's electricity problem

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Abstract: This work traces the causes of electricity problem in Nigeria to inadequate power generation. Though other militating factors such as faulty transmission and distribution systems were highlighted, the study insists that the major contributing factor to the epileptic electric power supply in the country is due to the inadequate power generation system currently in place. The study further proposes an integrated powers supply system whereby several sources of primary energy are harnessed and combined to give a robust generation system, as the solution to the epileptic power supply in the country. The study further recommends that the reactivation and repairs of the country's power transmission and distribution networks, is germane to the attainment of this goal.

Keywords: Distribution system, Energy resources, Integrated Power supply system, Power generation, Transmission system

INTRODUCTION

One of the major problems confronting Nigeria and militating against her development is the electricity supply problem. It is a major factor for the dwindling of the nation's economy.

Many small scale businesses which are the agent of economic growth have wounded up due to epileptic power supply. Many manufacturing companies have closed down and moved to other countries like Ghana where the public electricity supply is constant and more stable.

In spite of the participation of the independent power producers (IPPs) in the energy sector, reprieve is yet to come as people and industries continue to suffer (Charles, 1980).

The Table 1 below compares the interruption per year in some countries, with that of Nigeria.

CURRENT POWER SITUATION IN NIGERIA

A graphic detail of the power problem in Nigeria is necessary at this junction. In November 2008, power generation was as low as 2000 Mega Watt. By November 23, 2009, the state owned company, Power Holding Company of Nigeria (PHCN) announced a loss of 800MW and later a complete shutdown of its power station in Sapele, Delta State. The state owned power company, PHCN also claimed that its power station at Egbin Lagos State was operating at a reduced capacity. When President Musa Yar Adua came to power on May 29, 2007, the nation was generating about 3200MW of electricity. The situation has not improved despite all the promises made by the Government.

Unfortunately, majority of Nigerians have no access to electricity and the supply to those provided is not regular (Okoro and Madueme, 2004).

Current power generation: Currently, Nigeria relies on hydropower stations and gas-fired thermal stations to generate the electricity. Though Nigeria has a coal reserves of about 4 billion tones (Simolowo and Oladele, 2012), it is doubtful if the coal thermal station in Enugu is operational at all.

In November 30, 2009, Oben and Egbin gas plants were shut down because of the activities of vandals who attacked gas pipelines. Much earlier, in February 23, 2001, the failure of a by-pass valve shutdown all power generation stations. Reports of the breakdown or reduced efficiency of hydro stations at Kainji and Shiroro dams have been widely reported in the news. Most often, this is attributed to either heavy down pour or dry season. In a nutshell, the primary energy resource as currently exploited for power generation in Nigeria is grossly inadequate.

Government intervention to boost power generation – The Nigeria independent power project (NIPP): In order to boost power generation, the Federal Government embarked upon the independent power project (IPP).The first phase of the NIPP, comprise 12 power stations, 102 transmission lines and 22,000 transformer, this project would have added 7,600MW to the national grid. The 12 power stations are the Omoku thermal power station, River state, Gbaran/Ubie thermal power station, Bayelsa State, Sapele thermal, Ihorbor thermal power station, Imo

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state and Calabar thermal power station Cross River state (Ikeme and Obas, 2005). The four PHCN power projects is Geregu, Omotosho, Papalanto and Alaoji, whose construction had reached advance levels, before NIPP idea was conceived, were later brought under it for managerial convenience.

The second phase of the NIPP was intended to add 2,400MW to the nation grid. Contracts for the upgrading and expansion of Egbema, Omoku and Gbaran power stations were included under the second phase. Also included under the second phase were contracts to be awarded for the construction of new power stations and transmission lines at Ota, Ogorode, Agbara, Magboro, Brass and Bonny, Project under the third phase were not made public before President Yar'Adua's predecessor left office.

In all, the NIPP was estimated to cost the nation $3billion, about N362 billion, to contractors and consultants. From this amount 18 gas turbines were bought.

The Independent power project has not solved the epileptic power problems in the country due to many factors, such as shortage of gas supply to the thermal stations, vandalism, and inadequate transmission networks.

CAUSES OF POWER FAILURE

The identified causes of power failure are itemized as follows:

(1) Problem of insufficient power generation in the face of Abundance energy resources

(2) Non-expansion of the transmission and sub-transmission lines.

(3) Faulty and unconventional distribution network

(4) Uncontrolled consumption.

Power generation problems: The primary energy sources used in Nigeria for the generation of electricity are majorly hydropower and gas. Despite the huge reserve of coal in Nigeria, it is not exploited for power generation. Compare this to South Africa which generates about 35,000 MW of electricity via coal-fired power plants. Coal plays a vital role in electricity generation worldwide as shown in Table 2.

Other primary resources exploited for electricity generation in the world apart from coal which is 41% are gas 20%, hydro 16%, Nuclear 15%, Oil 6% and others 2%. The implication of this is that the Nigerian generating system is grounded whenever there is a problem with the gas and/or hydro sources.

Non-Expansion of the transmission and Sub-transmission lines: Ordinarily, when one conceives the ideals of generating electricity, the next thing one should think about is the expansion of the transmission lines. But in Nigeria the scenario is quiet different. The stakeholders should not think about the expansion of the national grid alone when commissioning new generating stations. For example the Papalanto and Omotosho power station had been commissioned but the power generated had not been transmitted out of the station because the transmission lines had not been expanded to that site. Hence, transmission of power to the end-users is as important as its generation. In all, non expansion of the transmission lines is also one of the causes of power failure, in Nigeria.

Faulty distribution network: Many of our distribution networks are faulty. Transmission lines crises crossing one another indiscriminately are common sights in Nigeria cities. Many of the lines in the city are old and damaged and most time sparks intermittently leading to power loss. Many of the wires in the distribution networks and transmission lines are due for replacement. One other problem of aged wire is large dissipation of power. Further still, the distribution network is often overloaded during peak period without equivalent supply from the generation process. This strains the network. Finally, the activities of man such as bush burning also affect the durability of the wires drastically. As a matter of fact, these activities have been responsible for some towns being cut-off from the main networks.

Uncontrolled rate of consumption: The rate of consumption of power in Nigeria is often totally, neglected by the power producing company (PHCN) and the consumers have taken advantages of this. For example, all sort of illegal connections are made with any kinds of wires without minding the effect on the system as a whole. It is essential to use a standard wire because of power dissipation. Some wires are meant for high tension and others for domestic uses but in Nigeria

Table 1. Comparison of power interruption in some countries.

Countries	Power interruption per year in minutes
Singapore	15
France	52
USA	88
Ghana	60
Cote D'Voire	120
Nigeria	60,000

Source: Hadi (2006)

Table 2. Coal in electricity generation.

South Africa	Poland	PR China
94%	93%	81%
Australia	Isreal	Kazakhstan
76%	71%	70%
Greece	Czech Rep	Morocco
55%	62%	57%

Source: Charles (1978)

Table 3. Energy resources in Nigeria.

S. No.	Resource	Amount in Resource	Amount set to be explored
1	Oil	36.5 billion barrels	160 trillion cubic feet (tcf)
2	Gas	187.44 tcf	130 tcf
3.	Bilumen ad tar	30 million barrels	----------
4.	Coal and lignite	4 billion tones	Not fully harnessed
5.	Hydropower (large and small)	Potentially 14,750 Mega Watt	Not fully harnessed
6.	Wind power	Potentially 5,000 mega Watt	Unexploited
7.	Solar	Potentially 3,000 mega Watts	Sparingly used

Source: Simolowo and Oladele, 2012.

Table 4. Highlights of different Energy Sources used in other countries.

Sources	Countries	Install capacity	Year
Wind power	World wide (especially European Countries and USA	121,000MW	2007
Photo voltaic	Germany	6,900MW	2007
Solar thermal	U.S.A	354MW	2007
Geothermal	California, USA	750MW	2007

Source: Rao and Parulekar, 2007

nobody cares about the types of wire that is used in connection. Some people could even use flexible wires. To make the case worse, most people leave their incandescent bulb, which consumes a lot of power, switched on for 24hours. In effect, generated electricity is wasted. It was found that an estimated 70 percent of urban dwellers leave their incandescent bulbs switched on, even when there was no need for illumination (Agboola, 2011).

THE INTEGRATED POWER SUPPLY SYSTEM AS THE SOLUTION

Having identified the inadequacy and the challenges of the present energy sources, there is a need to expand and diversify the power generating system. Nigeria needs not rely on hydropower and gas only for its generation of power. Other sources such as coal, wind power, solar, geothermal, biomass should be exploited as it is being done in developed countries. Infact, no nation of the world uses two or three primary energy resources to generate electricity and maintains a constant/ uninterrupted electricity supply (Rao and Parulekar, 2007). Most developed and developing nations where electricity supply appears to be stable use sources ranging from gas, coal and other thermal sources to renewable sources such as hydro, wind, tidal, solar, biomass, Geothermal etc. (Rao and Parulekar, 2007).

Nigeria is richly endowed with several primary energy resources as shown in Table 3 which if properly harnessed will make the power problem in the country a thing of the past.

Similarly Table 4 gives a global view of different energy sources being used in other countries which Nigeria can copy.

While power generation in Nigeria oscillates between 2,000MW and 6,000MW, it is about 40,000MW in South

Table 5. Power generation capacity in the United State of America**.**

Type	Capacity (MW)	Percent	Fuel
Steam Plant	478,800	63	Coal, gas petroleum
Nuclear	106,400	14	Uranium
Hydro and pumped Storage	91,200	12	Water
Gas turbine	60,800	8	Gas, petroleum
Combined cycle	15,200	2	Gas, petroleum
Internal combustion	4,940	0.65	Gas, petroleum
Others	2,660	0.35	Geothermal Solar, wind
Total	**760,000**	**100.0**	

Source: Hadi (2006)

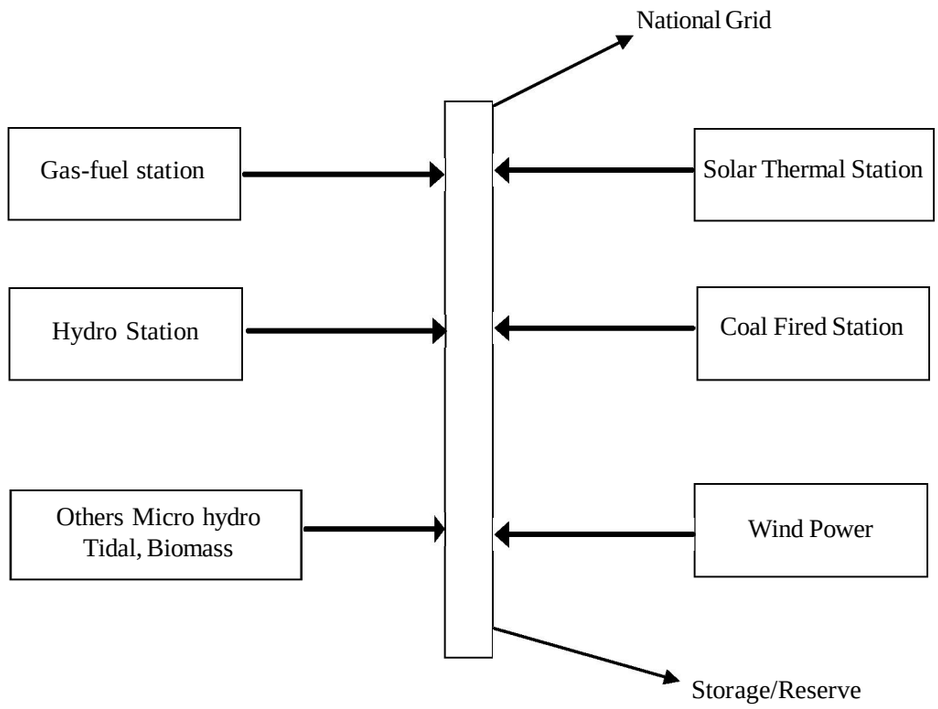

Fig. 1. *A model of the integrated power supply system (IPSS).*

Table 6. Power generation in India.

S. No.	Power plant	Power generated in Year 2000 in MW
1	Coal Fired System thermal power plant	67,000
2	Combined cycle, gas fired power plant	8,000
3	Hydro power plants	20,000
4	Nuclear fission power plants	3,000
5	Non-conventional power plant	2,000
	Total	**100,000**

Source: Rai (2004)

Africa and about half of that in Ghana. Power generation in USA and India are even much more. The installed generation capacity in the United State of America is highlighted in the Table 5. Another example is given in Table 6 in this case, India.

Renewable energy technologies are also suited to small scoff-grid applications, sometimes in rural and remote areas where energy is often crucial in human development. For instance, Kenya has the world's highest household solar ownership rate with roughly 30,000 small (20-100 Watt) solar power systems sold per year. Nigeria can tap into Micro hydro systems which are well suited for water rich areas as a Remote Area Power Supply (RAPS).

Table 7. The regional grids.

Grid	Location	Resources
A	Southern region	Coal, geothermal, solar, gas, biomass
B	Eastern region	Coal, geothermal, gas, biomass
C	Northern region	Solar, solar (PV), geothermal, wind and biomass
D	Western region	Solar, gas and biomass

What then is the integrated power supply system?

This is a system whereby the identified energy resources are harnessed and inter-connected into a main energy reservoir for effective distribution to all parts of the country. A proposed model is displayed graphically below:

Workability of the model: The proposed model will only work if the other identified problems are fixed. This includes:

1.The expansion of the transmission and sub-transmission lines

2. Re-organized and efficient distribution networks. These are discussed below

Revival of the transmission lines: The transmission lines

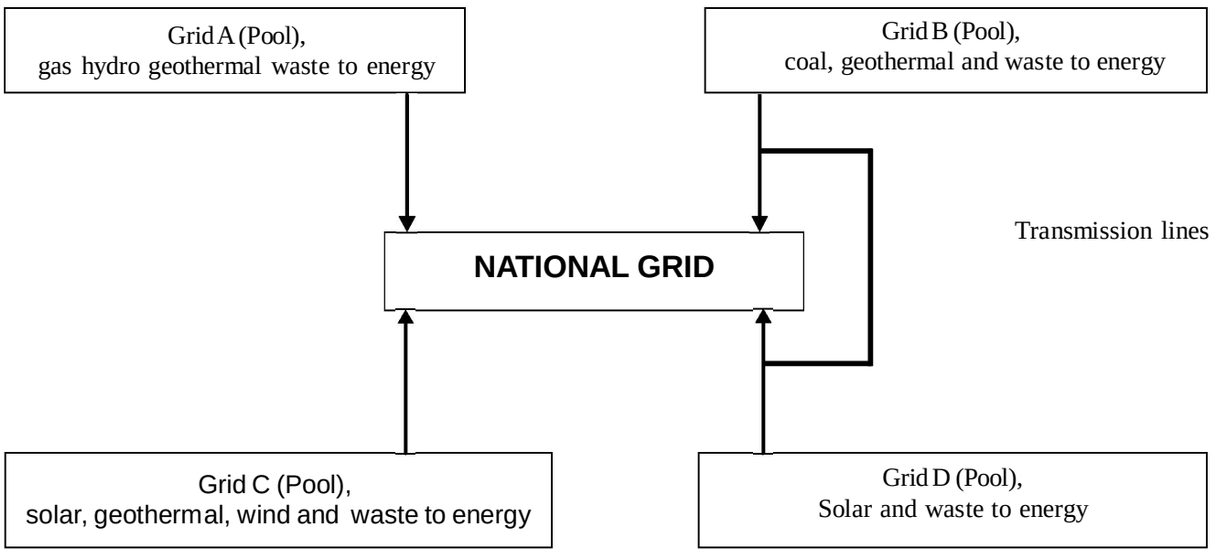

Fig. 2. *A model of the new power system.*

should be expanded rapidly, into regional grid. The whole essence is to have disintegrated transmission lines but an integrated national grid. There shall be a control center, which will match the power generated to maintain the system frequency (50Hz) with the target limit. In addition, surplus power is exported or deficit power is imported by the region. The national grid is formed by the interconnection of the regional grids.

The selection of an economical voltage level transmission line is based on the amount of power and the distance of transmission. The voltage choice together with the selection of conductor's size is mainly a process of weighing RI^2 losses, audible noise and radio frequency interference level against fixed charges on the investment. To reduce these losses, the transmission lines should be located in short distances from the distribution network voltages above 230KV should be bundled. Bundling, which means the use of more than one conductor per phase, increases effective radius of line conductor and reduces the electric field strength near the conductors, which reduces corona power loss, audible noise and radio interference.

Revival of the distribution networks: It is pertinent that the distribution networks and the transmission line are susceptible to the same types of losses. These losses as enumerated above could be reduced by increasing conductor size and the use of bundle. It has been assumed that the distribution network has been expanded and deteriorated conductors have been removed from the networks. Another effort to reduce losses is the reduction of the 220V for domestic use to 110V. At this level power dissipated (=IV) along the distribution network will reduce.

REGULATION OF CONSUMPTION RATE

There should be a consumption regulation authority which will set the standard for the kind of cables that consumers will use. This body will also ensure that the current incandescent bulb that is in common use is stopped. This bulb consumes a lot of power and dissipates same as heat.

Finally, the energy consumption rate regulation authority should apart from taking full responsibility of the consumption rate, orientate the users on the need to form energy storing habit. For instance, any appliance and bulbs that are not in use should be switched off.

The national grid for the energy supply system: The proposition is that the national grid be divided into at least four regional grids. The division should be made in consideration of the availability of resources in the geographical distribution, status of technology and economics amongst other factors. The Table 7 below illustrates this.

The regional grids would be interconnected to form the national grid in the interconnected power system. The power generated in various power plants is pooled by the network of transmission lines covering the entire nation.

In the interconnection of the regional grid, it may be more economical to convert extra high voltage (EHV) ac to (EHV) dc, transmits the power over two lines, and inverts it back to ac at the other end.

This is because; it is more advantage to transmit dc when transmission distance is 500km or more. Dc lines have non reactance and are capable of transferring more power for the same conductor size than ac lines.

Recommendations

The ministry of power should involve a long-term fuel policy for power generation in consultation with concerned ministries taking into consideration, the

availability of resources, their geographically distribution, status of technology, economics of their utilization and environment aspects.

Autonomy should be given to states, private and other powers utilities to generate electricity. These should be structured for higher efficiency.

Tariff board should be at the national and regional level for regulating the tariff policies of public and private utilities.

Private sector should be involved in the generation and supply of power to well identified area and in the installation of regional power stations.

The power grids should function as a clearing house for exchange of power between the regional zones and states.

Most of the existing transmission lines should be repaired or overhauled.

Wiring and external cable connections should follow strict regulation to stem the issue of indiscriminate wiring / networks.

Step-down transformers should be deployed in abundance to help in the distribution system and reduce current case of overloading.

Conclusion

Undoubtedly, with the right drives, policies, regulations and commitment in place, Nigeria can generate up to 70% of its electricity need by harnessing all the available resources.

With the abundance of coal reserves, many coal-fired power plants should be established to complement the existing ones. It is also not impossible to have wind farms in the vast dry land of the north to exploit wind power.

REFERENCES

Agboola, O.P. (2011). Solution to Nigeria Power Generation Problem. *Proceedings of the World Congress Engineering*. 3(2), 11-17

Charles, S.M.A. (1978). Coal its Role in Tomorrow's Technology, Pergamon Press Ltd, Headington Hill Hall, Oxford OX3 OBW, England.

Charles, S.M.A. (1980). Hydro Power the use of Water as an Alternative Source of Energy, Pergamon Press Ltd, Headington Hill Hall, Oxford OX3 OBW, England.

Hadi, S. (2006). Power System Analysis, 2nd Edition. The McGraw-Hill Companies, Inc. 1221 Avenue of Americas New York, NY 10020.

Ikeme, J. and Obas, J. E. (2005). Nigerians Electric Power Sector Reform: The Key Objectives

Okoro, O.I. and Madueme, T.C. (2004). Solar Energy Investment in a Developing Economy. *J of Renewable Energy,* 29(2), 1599-1610.

Rai, G.D. (2004). An Introduction to Power Plant Technology, 3rd Edition, Romesh Chandler for Khanna 2-B, Nath Markel, Nat Sarak Delhi-110006, India.

Rao, S. and Parulekar, B.B. (2007). Energy Technology, 3rd Edition, Romesh Chandler for Khanna 2-B, Nath Markel, Nat Sarak Delhi-110006, India.

Simolowo, O.E. and Oladele, S. (2012). Energy-Cost Analysis of Alternative Sources to Electricity in Nigeria. *Indian J. of Sci and Tech.*, 5(1), 1946-1952.