A Critical Review of Grid Operations in Nigeria.

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ABSTRACT

The grid is a network that connects all the major power stations and load centers in a country (or power system). The constraints to grid operations include generation, transmission, and system control. Remedial actions aimed at addressing these problems are presented. The high point of the recommendations is the adoption of "Distributed Generation Scheme". In the absence of an accurate load demand, regional sales of electric energy were used to estimate regional demand for electricity. These were in turn used to decide location of new generating plants under the distributed generation scheme.

(Keywords: grid operations, energy sales, distributed generation)

INTRODUCTION

Most large and efficient generating stations generate at 10.5-16kV and feed through transformers into the grid with a primary transmission voltage of 330kV. The grid feeds a sub-transmission network operating at 132kV. This network supplies network for distribution at 33kV, 11kV, and 415/240V. The national control center (NCC) is at Osogbo.

Some of these transmission lines are so long that by the time the power gets to its destination the voltage would have dropped considerably. Furthermore communication between NCC and some distant generating stations and load centers is not very reliable. This makes system control a bit difficult. The communication equipments can be upgraded but we believe that distributed generation will be much easier to operate and control will be a lot easier too.

CONSTRAINTS TO GRID OPERATIONS IN NIGERIA

The constraints to grid operations in Nigeria include communication, generation and transmission line constraints.

Communications Constraints

Without adequate and functional communication facilities in place power generation ordering and load dispatching will be impossible. The effect of this includes the following: Inability of the system operators to disseminate operational information, delay in restoration of the power system in case of system collapse, elongation of equipment downtime, customer dissatisfaction, and loss of revenue for the company. The obsolete communication equipment that still exists in some areas constitutes bottleneck in information dispatch by the NCC system operators.

Theft of communication cables also constitutes a serious problem in system communication. Communication to Lagos areas was disrupted by the stealing of sky wires and fiber optic cables between Ayede and Ikeja west in 2005. In view of the tremendous benefits of fiber optics communication medium, it could be used to improve the state of communication within the system.

Generation Constraints

As at 2005 the total site ratings of installed capacities at all PHCN (Power Holding Company of Nigeria) power stations was 6656.40MW. Out of this, the average available capacity was 3736.55MW. The availability factor stood at 56.13%. This figure has been on the decline since then for so many reasons including ageing of the generating units.

Transmission Line Constraints

Ageing and lack of maintenance are some of the problems facing the transmission lines in Nigerian power system. Ikorodu-Ayede-Osogbo 132kV line was constructed around 1964. There are quite a few transmission lines like this and they are poorly maintained. Akangba-Ojo 132kV line is a typical example of a poorly maintained line.

Another problem is the length of the transmission lines. The Gombe-Maiduguri 132kV line is about 310km long with the consequent large voltage drop. The New Haven-Oturkpo-Yandev 132kV line is 330km long. The voltage drop between New Haven and Yandev is about 20kV.

The third problem with the Nigerian grid system is the lack of alternative route for the primary transmission lines. Benin-Onitsha-Alaoji 330kV line is a typical example. If there is a trip on this line for whatever reason the situation will be very grave. This singe line contingency is also applicable to the Aba-Itu 132kV line. The Aba-Itu line serves Aba, Itu, Calabar and Eket and all these areas will be affected in the event of any outage.

CONCEPT OF DISTRIBUTED GENERATION

Distributed generation means the production of electricity from many small energy sources. It has also been called on-site generation, dispersed generation, embedded generation, decentralized generation, decentralized energy or distributed energy (Wikipedia, 2007). Most industrialized countries generate their electricity in large centralized facilities such as coal power plants, nuclear reactors, hydropower or gas powered plant. These plants have excellent economies of scale, but usually transmit electricity over long distances. Distributed generation reduces the amount of energy lost in transmitting electricity because the electricity is generated very near to where it is used. This also reduces the size and number of power lines that must be constructed.

Typical distributed power sources have low maintenance, low pollution and high efficiencies (Wikipedia, 2007). The usual problem with distributed generators is their high costs. The one exception is probably micro-hydropower.

The traditional model of electric power generation and delivery is based on the construction of large, centrally located power plants. Regardless of where power plants are located, their power must be brought from the plant to the users and that is the purpose of the electricity grid (Anne-Marie Borbely et al., 2001). The grid consists of high-voltage transmission systems carrying electricity from the power plants to load centers, from where low voltage distribution networks take the power to customers.

From about 1985, electric utilities began to anticipate the likelihood of increased competition (Budhraye Vikram, 1999). Building of large power plants were viewed as a risky move and programs to encourage energy efficiency and load reduction (Demand-side management) became popular as one alternative to power plant construction (Basso, T. S., et al., 2003).

Implementing distributed generation can be as simple as installing a small generator to provide back up or it can be a complex system, highly integrated with the electricity grid and consisting of electricity generation, energy storage and power management systems. Distributed generation can support and strengthen the central station model of electricity generation, transmission and distribution. While the central generating plant continues to provide most of the power to the grid, the distributed resources can meet the peak demands of local distribution feeder lines or major customers.

Utility deregulation and the growing challenge of system reliability are the primary reason for the high level of interest in distributed energy resources. Others are desire for alternative renewable resources such as solar and wind, need for higher power quality in some commercial and industrial facilities as a result of increased use of microelectronic devices, remote power applications and to reduce the high expenses incurred in transmission of power and also to meet requirements for reduced emissions.

Distributed Generation for Power Quality and Reliability

In certain commercial and industrial electrical applications, it is critical that high quality and reliable uninterrupted power be supplied, in order to prevent significant economic losses that can be incurred due to power cuts.

Utility restructuring, technology evolution, public environmental policy and an expanding electricity market are providing the impetus for distributed generation to become an important energy option today (Rahul Walawalker, 2007). While central power systems remain critical to the Nation's energy supply, their flexibility to adjust to changing energy needs is limited due to large, capital-intensive plants and transmission and distribution grid. Need for high investments and transmission losses have led to power shortages, unreliable and costly power being the rule rather than exception.

Interconnected distributed energy resources can provide many beneficial services. At the most basic level, they can provide on-site electricity in the event of an outage on the electric power system. In more complex cases, appropriate interconnection technologies and policies can allow small energy producers to sell excess energy back to utilities.

When effectively integrated into an electric power system, distributed power systems can be used to provide high value energy, capacity and ancillary services such as voltage regulation, power quality improvement and emergency power. Distributed energy resources (DER) refers to a variety of small, modular power-generating technologies that can be combined with energy management and storage systems and used to improve the operation of the electricity delivery system, whether or not those technologies are connected to an electricity grid (Rayhul and Vaidyanath, 2007).

They are parallel and stand-alone electric generation units located within the electric distribution system at or near the end users. DER can be beneficial to electricity consumers. Their generating capacity is typically in the range of 3 to 50MW.

Stability of Power Systems with Large Amounts of Distributed Generation

The impact of distributed generation to a large extent depends on the penetration level of the distributed generation in the distribution network as well as on the type of distribution technology and its mode of operation (Valerijs Knazkins, 2004). If distributed generation is properly sized, sited and selected in terms of technology, it can clearly provide benefits to control, operation and stability of the power system. It should however be noted that distribution networks have traditionally a rather inflexible design, mostly unidirectional power flow. This creates integration problems with higher distribution generation penetration levels or different technologies. However, this can be solved by modifying the distribution network. (Valerijs Knazkins, 2004).

One of the most essential factors influencing the interaction between the distributed generation and grid is the technology utilized in the distributed generation as well as the mode of distributed generation control and operation.

STRENGTHENING THE NIGERIAN GRID USING THE DISTRIBUTED GENERATION

As already mentioned in section 2.2 of this paper total generation in Nigeria was 3736.55MW in 2005 (representing an availability factor of 56.13%) and has been on the decline since then. The electric energy sales in the six electricity regions of the country are shown in Table 1. Although the figures do not represent the real electric energy demand of these regions (because you cannot sell what you do not have), they nonetheless give an indication of electricity demand of each region. These figures can be used to work out the capacities and locations of the generators that will form the proposed distributed generation scheme to address the gross inadequacy in electric energy production in Nigeria. The type of plant in each case will be influenced by the availability of the primary fuel for that plant. For instance more stem plants could be built in Lagos region to support Egbin and AES plants there.

The Shiroro region (North East) could be strengthened by building a micro hydro power plant. Renewable energy, such solar could be used to boost electricity production in the Kaduna region. For the Benin region more thermal plants located in this region. Finally, solar and hyro plants are recommended or the Bauchi region.

CONCLUSION

We have seen that the present Nigerian grid is facing the problem of poorly maintained long transmission lines, inadequate communication facilities and insufficiency in power generation. Remedial actions have been recommended. But the large land mass makes the Nigerian power system very unwieldy and as a result difficult to manage.

Table 1: Electric Energy Sales in the Six Energy Regions of the Country.

i	**Lagos Region** (Akangba, Ikeja-West, Osogbo and Ayede Area Transmission Injection points)	9433991.76MWH (44.08%).
ii	**Enugu Region** (New Haven, Onitsha and Alaoji Area Transmission Injection points)	3823382.6MWH (17.86%)
iii	**Shiroro Region** (Shiroro, Birnin Kebbi, Jebba and Katampe Area Transmission Injection points)	2810331.00MWH (13.13%)
iv	**Kaduna Region** (Kaduna and Kano A. T. injection points)	2276486.39MWH (10.64%)
v	**Benin Region** (Benin, Ajaokuta and Aladja Area Transmission Injection points)	2011081.32MWH (9.40%)
vi	**Bauchi Region** (Gombe and Jos Area Transmission Injection points)	1046592.8MWH (4.89%)

We therefore think that the system could be broken into six semi-autonomous power systems. These power systems, covering the six geo-political zones, could be linked by tie-lines for export and import of electric energy.

The breaking up pf the Nigerian grid into six sub-systems paves the way for the adoption of distributed generation. The beauty of the distributed generation system has already been discussed in section 3 of this paper. So in making up the shortfall in electric energy generation, the new plants will be distributed among the six semi-autonomous grids. The capacities of these plants will be determined by the demand for electricity in each of these zones. This structure will definitely result in a manageable size power system. Excess power from any zone can easily be transported (exported) via the tie-lines to a zone that is in need of the electricity.

The networks within a zone can easily be monitored to ensure stability. Power quality and reliability of supply will improve.

With the above recommendations we will end up with an improved and more efficient power system than the present Nigerian grid.

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