

Investment in Electricity Generation and Transmission in Nigeria: Issues and Options

By Akin Iwayemi*

Substantial expansion in quantity, quality and access to infrastructure services, especially electricity, is fundamental to rapid and sustained economic growth, and poverty reduction.¹ Yet, for the past three decades, inadequate quantity and quality and access to electricity services has been a regular feature in Nigeria, a country with 140 million people with a majority living on less than US\$2 a day. The electricity industry, dominated on the supply side by the state-owned electricity utility, National Electric Power Authority (NEPA), and succeeded by the Power Holding Company of Nigeria (PHCN), has been unable to provide and maintain acceptable minimum standards of service reliability, accessibility and availability.

Nigeria's electricity crisis is striking for a variety of reasons. First is its occurrence despite the enormous endowments of non-renewable and renewable primary energy resources. The resource endowments of crude oil and natural gas currently estimated at 35 billion barrels and 185 trillion cubic feet, respectively, are more than adequate to fuel much of Sub-Saharan Africa (SSA) energy demand for several decades.² Coal reserves are also substantial at 2.75 billion metric tons. Also, large amount of renewable energy resources including hydro electricity, solar, wind and biomass energy are present. One of the many paradoxes in Nigeria is energy/electricity poverty amid plenty. Second, despite being a world ranking exporter of liquefied natural gas (LNG), Nigeria's gas-dominated electric grid experienced frequent collapse linked largely to inadequate gas supply. Gas pipeline vandalisation associated with resource control-linked militancy in the oil producing Niger Delta has compounded the supply problem. Huge gas flaring has been a regular feature of the Nigerian oil industry since production began in 1958.³ This wasteful gas flaring has consistently ranked Nigeria among the world's largest source of carbon emissions, a major factor in global warming. Third, the several billion dollars of public investment that went into generation and transmission capacity expansion in the past decade contrasts sharply with the extremely poor outcomes measured by frequent power outages and voltage variation.⁴ Fourth, there are the high social, economic and environmental effects of poor public power supply and its extensive substitution with highly polluting generators. Anecdotal evidence suggests that Nigeria has one of the highest concentrations of generators globally. The negative impact of the ubiquitous generators on environmental quality and the health of the population has elicited major concerns particularly among environmental and health scientists. Fifth is the depth and duration of the electricity crisis despite the availability of energy resource endowment and two decades of major economic reforms that commenced with the adoption of the Structural Adjustment (SAP) in 1986.

The limited scope of this paper precludes any detailed analysis of the wide ranging impact of the crisis.⁵ Unquestionably, Nigeria's electricity crisis significantly undermined the effort to achieve sustained economic growth, competitiveness in regional and global markets, employment generation and poverty alleviation. Arguably, apart from the "curse of oil", the "curse of electricity", apparent in the intractable black-outs and brown-outs and pervasive reliance on self-generated electricity, is the most enduring of the series of economic and social adversity that have battered the Nigerian economy in recent decades.⁶ The persistence of the crisis under successive governments seems to suggest that the adverse impact of the "curse of electricity" on socio-economic development and living standards was hardly appreciated. The prolonged dismal electricity industry performance has been the most intractable infrastructural problem and policy challenge in the last half a century.

In recent years, there seems to be a better appreciation of the gravity of the infrastructure problem as apparent in various policy initiatives. This combined with the severity of the service failures made possible wide public acceptability and political feasibility of electricity market liberalization. These developments facilitated the passage of the comprehensive Electric Power Sector Reform Act (EPSRA) in 2005. EPSRA embodies radical reforms which if well implemented should produce a robust and competitive electricity industry where unreliable and inadequate service would be the exception rather than the rule. Two significant outcomes of the albeit gradual implementation of the EPSRA, are: the establishment of a regulatory agency, Nigerian Electricity Regulatory Commission, NERC, in 2005; and the unbundling of the industry into six generation, one transmission and eleven distribution companies in 2007.

Despite recent policy initiatives, institutional developments such NERC, the last minute effort of the previous Obasanjo administration to tackle the crisis through the ambitious National Integrated Power Project (NIPP), the

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See footnotes at end of text.

electricity crisis has not abated. NIPP involved the government constructing several power plants to add 1374 MW new capacity to the grid. Ironically, though, the electricity crisis has deepened, the new government has suspended the NIPP citing constitutional reasons associated with its financing from excess crude funds.

Perspectives on Nigeria’s Electricity Crisis

The discussion in this section contains a few historical and contemporary reference points to capture the essence of the nature of the electricity crisis since 1970. Figure 1 shows the trend in transmission and distribution losses. Transmission and distribution losses in the double digits are extremely large by international standards. The system losses are five to six times those in well-run power systems, and are among the highest in the world.⁷ The high level of power losses is symptomatic of the technical inefficiency of the industry. Reducing the losses to single digits is a major challenge facing the Nigerian electricity industry.

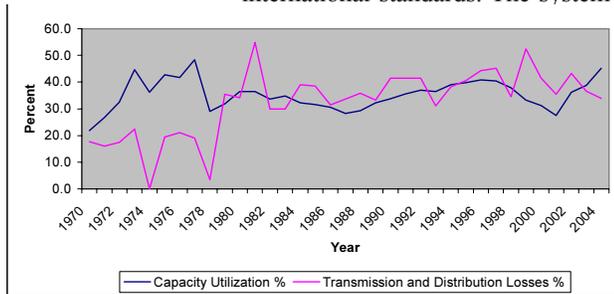


Figure 1 Indicators of Electricity Crisis in Nigeria 1970-2004

Source: Derived from Central Bank of Nigeria Statistical Bulletin Volume 15, December 2004

The trend in capacity utilization in Figure 1 demonstrates another dimension of the electricity crisis. The low and unstable capacity utilization, evident in average capacity utilization of less than 40% during the period, shows the large gap between installed and actual operational capacity. The role of insufficient operational capacity due to ageing facilities that are poorly maintained is indisputable. Notably, despite the size of inoperable capacity, no new plant has been added to the grid since 1990 (Table 1).

Table 1 shows the profile of the hydro-thermal plant mix. Currently gas powered plants dominate the system. The infrastructure facilities are not only old, they are also beset by water flow and gas supply problems. The water flow problems which have seriously undermined the performance of the three hydro stations in recent years are linked to reduced water volumes in the River Niger and its tributaries due to climate change. Increased frequency of gas supply disruptions to gas-fuelled generating plants have also reduced electricity generation. Recently, gas pipeline attacks from associated resource control militancy remains a scourge on the industry.

Station	Plant Type	Installed Capacity	Generation	Actual Generation	Year(Units) Installed
Kainji	Hydro	720	303	283	1968,1976,1978
Jebba	Hydro	720	475	278	1983,1984
Shiroro	Hydro	600	600	434	1989,1990
Egbin	Steam	1320	880	839	1986,1987
Sapele	Steam	720	180	179	1978,1980
Sapele	Gas Turbine	300	Not operational		1981
Afam (IV)	Gas Turbine	450	Not operational		1982
Delta (IV)	Gas Turbine	600	210	210	1990

Table 1 Installed and Actual Generating Capacity (Mw) 2004

Source: NEPA, Generation and Transmission Abuja.

Peak demand has been less than half of installed capacity in the past decade, yet, load shedding occurs regularly. This poor service delivery has rendered public supply a standby source as many consumers who cannot afford irregular and poor quality service substitute more expensive captive supply alternatives to minimize the negative consequences of power supply interruptions on their production activities and profitability. An estimated 20 percent of investment in industrial projects is allocated to alternative sources of electricity supply.

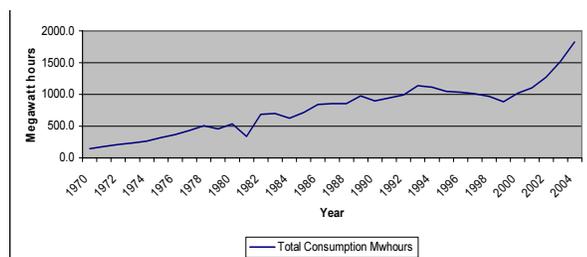


Figure 2 Electricity Consumption 1970-2004 in MWhours

Source: Derived from Central Bank of Nigeria Statistical Bulletin Volume 15, December 2004

The trend in electricity consumption is shown in Figure 2. Three observations emerge from the data. First is the low level of consumption. In 2004 less than 2000 MW-hours of electricity was consumed in a country of 140 million people. Second, the growth rate was relatively low for most of the period between 1970 and 1999 mainly because of suppressed demand line losses. Third is the remarkable turnaround in demand growth in the post 2000 period, a reflection of some improvements in grid supply.

A final perspective on the crisis is evident in the outage experiences of Dunlop PLC, a major multinational manufacturing firm. In 2004, it experienced 316 outages. Outages in 2005 jumped to 405 an increase of 26%. This was followed by an explosive 43% increase between 2006 and 2007, from 553 to 791.⁸ Besides, the incidence of outages was 100 in October 2007.

In summing up the discussion in this section, poor electricity service is the outcome of:

- Ageing and poorly maintained generating, transmission and distribution infrastructure facilities failures.⁹
- Weak financial and economic health of the state-owned company NEPA/PHCN. This derived from the prevalence of a regime of price control that had little concern for cost recovery. There were inadequate economic incentives for the company to engage in efficient production and investment behaviour due largely to the price subsidies and cross subsidies. The multiplicity of economic and non-economic objectives associated with state ownership imposed a social welfare-oriented pricing policy that did not generate sufficient profit margin. Notably, the largest debtors to NEPA were the federal, state and local governments.
- Weak institutional framework and governance failures. The institutional and governance failures induced gross inefficiency in production, distorted investment choices and demand patterns, high costs of operation, low return on investment and expensive delays and cost overruns that encouraged widespread corruption.

Producing, Delivering and Accessing Adequate and Reliable Electricity in Nigeria: Issues and Options

Three facts define the scope of the investment problem and enormity of the policy challenges associated with the electricity crisis: the current low level of electricity and energy consumption per capita by global development standards; the dismal state of socio-economic conditions in an economy just recovering from almost two decades of poor performance and deepening poverty; and the low human development indicators.

A look at the numbers in Tables 2 and 3 provides some magnitudes regarding the scope of the investment problem. The wide electricity gap and poverty in Nigeria in comparative African terms are clear from the data.¹⁰ However, meeting the challenges of providing adequate, reliable and widely accessible electricity service involves more than summing up numbers (the mega-watts and the size of investment) and getting other technical things right. The fundamental question is answering the question: what should be done, given the resource endowment, the political, economic, technological, environmental constraints in Nigeria? In fact, the question should be enlarged to include the West African region, given the two ECOWAS initiatives, the West African Power Pool (WAPP) and West African Gas Pipeline (WAGP).

The investment challenge must be appropriately situated in the context of a constrained multi-objective incentive compatible optimization problem. They have several dimensions, namely, size, source, plant mix, security of investment and input supply, human resource requirements, investor/ producer incentives e.g., electricity tariff level and structure, regulatory framework and macroeconomic environment.

From the demand side, the current level of electricity demand underestimates the true level of demand given the high level of suppressed demand. The estimation of potential level and growth in demand must incorporate these factors for greater forecasting accuracy. Power is exported to the neighbouring Niger Republic and there are plans to connect Nigeria with other countries in ECOWAS through the West African Power Pool Project.

Based on these factors and the current decay in the grid, the numbers look staggering. According to a recent projection, generating capacity should increase from 6000 MW in 2007 to 35 GW in 2015, a six-fold increase.¹¹ This is expected to further triple to 105 GW in 2025 before slowing down to reach 164 GW in 2030. This system expansion is expected to eliminate current electricity poverty and raise electricity per capita from the current extremely low level of 140Kwh to 1,110kwh in 2015, 5,000Kwh in 2030. It is striking that Nigeria's per capita consumption in 2030 will be about 20% above the level that obtained in South Africa in 2003! In addition, since domestic demand must be examined in the context

Country	Per Capita Income US \$	Per Capita Electricity Consumption (Kwh)
Nigeria	430	140.2
Egypt	1250	1337.4
Algeria	2270	913.6
South Africa	3630	4559.5

Table 2

Electricity and Income Per Capita for Selected Countries in 2004

Source: Energy Information Administration, *International Energy Annual 2004*. DOE, Washington DC.

	Nigeria	Egypt	Algeria	South Africa
1980	2.240	4.867	2.185	18.383
1990	4.960	11.474	4.657	31.015
2000	5.85	17.861	6.044	39.817
2004	5.888	17.958	6.468	40.481

Table 3

Installed Power Capacity (GW) in Selected Countries 1980 to 2004

Source: Energy Information Administration, *International Energy Annual 2004*. DOE, Washington DC.

and integrated into the ECOWAS electricity framework, given WAGP and WAPP, and the proposed integrated energy market in West Africa, domestic electricity infrastructure investment and supply policies and promotion must be mutually consistent and coordinated with the rest of the region.

The projected amount of investment to meet this system expansion is estimated at about \$262 billion. This amount is enormous given industry experience. Though this financial requirement is daunting, it is achievable. The right institutional framework, policy consistency, appropriate incentive structure and security of investment and input would guarantee the required flow of investment. The successful privatization of the telecommunication industry which brought in about \$12 billion of investment provides support for this position. The turning around of a moribund public utility to a vibrant private sector-led industry with one of the fastest system growth rates in the world has been due to the combination of right institutional framework, policy consistency and appropriate incentive structure.

Both domestic and foreign investors and producers have important roles to play in achieving a sustainable electricity future in Nigeria. With the unbundling of PHCN into 6 generation companies, one transmission, and 12 distribution companies the sector is on its way to full deregulation and privatization. The companies are yet to be privatized. There is no universal “one model fits all”. But most power systems are private sector driven. A public-private sector mix can also be a viable option.

The peculiar nature and initial conditions in the industry may suggest some roles for the government in the production and delivery of electricity. This is particularly so if only one of the 23 Independent Power Producers (IPP) given licences by NERC to add 8237 MW to existing capacity, has done anything tangible. There is some reluctance among the licensees to begin observable construction activities. Part of the problem concerns the power purchase agreement (PPA) which is at the core of IPP. The unnecessarily long duration of PPA will lock in a high cost structure in the grid system because of the take or pay clause in the agreement. It poses a problem to cheaper production from more efficient plants in the future. The current AGIP IPP agreement is an example. It was partly to prevent being held to ransom that the Obasanjo Administration, as an interim measure close to the end of its tenure, embarked on a rapid expansion of generating plant capacity with assistance from the Chinese government. Three new gas-based power stations are now at various stages of completion. In all, seven power stations were planned to be constructed in the Niger Delta region to utilize flared gas under the abandoned but controversial National Integrated Power Project (NIPP). In addition, a new large 2,600MW hydro project costing US\$3.46 billion is also underway, with assistance from the Chinese government. Though the NIPP has been suspended, the decision should be revisited given the reluctance of the private sector. After construction, the plants can be privatized or concessioned to be run efficiently.

Clearly, government intervention through NIPP will moderate the scaling up in tariff that the sector requires to provide affordable and adequate electricity. Power pricing that would guarantee an attractive rate of return to investors adjusted for industry risk and security of investment and input are two important considerations in private sector investment in the industry. Effective implementation of the core reforms in the EPSRA would ensure industry operation based on global best practices.

One of the basic factors in securing the electricity future is the energy mix over the next several decades. Table 4 provides some indicators for alternative energy resources, non-renewable and renewable. While both energy resources will be used in the future, the continued dominance of fossil fuels supplemented by hydroelectricity is envisaged for the foreseeable future. Coal, hydro, solar, biomass, wind and nuclear energy technologies are alternative electricity generation options under consideration.

Developing and deploying cleaner energy should be part of the investment strategy with the focus, however, on progressively adopting cleaner fossil fuels based on renewable energy sources to meet rural electricity demand. Notably, the government plans to achieve 10% of the electricity supply from renewable resources by 2025.¹² Coal and nuclear energy are also on

the options list. 5000 MWe of nuclear generating capacity is expected by 2026.¹³ In pursuit of the nuclear power objective, the government and IAEA recently began discussion on identifying possible sites for nuclear power stations.

The mobilization of the financial resources to support a dramatic scaling up of generating capacity, more than twenty-fold in less than three decades, will be a major challenge. Besides this must be situated within the context of the risks that would impact the industry. Risks associated with investment to

Energy Type	Reserves Estimates
Crude oil	36 billion barrels
Natural gas	185 trillion cubic feet
Coal	2.75 billion metric tons
Hydro	14,750 MW
Solar radiation	3.5-7.0 kwh/m ² -day
Wind energy	2.0-4.0 m/s
Biomass	144 million tons/year
Wave and tidal energy	150,000 TJ/ (16.6 x 10 ⁶ toe/yr)

Table 4

Energy Resources in Nigeria

Source: Ibitoye and Adenikinju (2007)

strengthen power supply networks in both the short and medium term are in four dimensions: economic, socio-political, technological and environmental (methane leaks, climate change compatibility, nuclear accidents spills). Optimal sharing of these risks among the three principal market actors, namely, consumers, investor/producers and the state is essential for efficient allocation of resources in the industry for a sustainable electricity future in Nigeria and the sub-region.

The human resource requirements of robust and reliable generation, transmission and distribution systems, fundamental to a sustainable electricity future in Nigeria, is going to exert significant pressure on the demand for local and foreign skilled workers. Again, as in the telecom industry, having the appropriate incentive structure is essential given the globalized, regional and national demand for skills needed to support a vibrant Nigerian electricity industry, the hub of West African energy map.

Finally, there is the issue of security of supply of gas and gas pipelines associated with resource control agitation in the Niger Delta. Efforts to eliminate tension in the region is more urgent than ever before. Developing and procuring and applying best practices in the industry will impact the volume and quality of investment. The recent flow of gas through the West African Pipeline to power the economies of Ghana, Togo and Benin could also be subject to disruption.

Conclusions

The main conclusions of this paper are that the elimination of the electricity curse and emergence of the required strong investment response are contingent on:

- Radical changes to improve and strengthen industry governance structure to enhance accountability and minimize corruption;
- Strengthening the current reform effort in the industry to create a more competitive electricity market where market-responsive pricing predominates;
- Elimination or minimization of concerns about security of supply of gas associated with resource control agitation in the Niger Delta region. Credible and decisive effort to eliminate tension is more urgent than ever before.

Certainly, a new partnership would have to be forged between the public and private sectors to meet the emerging investment challenges. Ultimately, elimination of the curse of electricity in Nigeria goes beyond delivering adequate and reliable electricity to end-users. It also involves giving consumers widely accessible, affordable and environmentally friendly electricity service.

Footnotes

¹ For specific discussion about infrastructure and economic growth and development in Africa, see World Bank (2000). For more general discussion see World Bank (1994) and (2003).

² The share of Nigeria in global reserves of oil and gas is 3% (BP Statistical Review of World Energy).

³ The persistent flaring of oil-associated gas is partly due to the reluctance of multinational oil companies to invest in the gas gathering facilities for domestic use. Another factor has been their willingness to pay the low penalties for flaring gas.

⁴ The amount of public spending on electricity infrastructure between 1999 and 2004 far exceeded what was spent between 1981 and 1998 yet the crisis persisted. \$4 billion was spent during Obasanjo's Administration but capacity remained almost static, much below 4000MW.

⁵ For discussion on some estimates of the cost of electricity failure in Nigeria at the microeconomic level see Adenikinju (2005)

⁶ For more discussion on the curse of oil in Nigeria see Iwayemi (2006)

⁷ See Box 9.8 on page 175 World Bank (2003).

⁸ See Vanguard Newspaper, December 20, 2007 page 22.

⁹ No new generating capacity was added to the industry between 1991 and 2006 despite changes in the economy driven by the oil booms of the early 1990s and since 1999 to date.

¹⁰ See Ibitoye and Adenikinju (2005) for some analysis of the future electricity situation in Nigeria.

¹¹ This is taken from Ibitoye and Adenikinju (2005)

¹² See Energy Commission of Nigeria (2005)

¹³ See Energy Commission of Nigeria (2002).

References

1 Adenikinju, A (2005) Analysis of the cost of infrastructure failures in a developing economy the case of electricity sector in Nigeria. African Economic Research Consortium AERC Research Paper 148, February 2005 Nairobi.

2 Ayogu, M (2006) Infrastructure Development in Africa: Prospects and Challenges. Paper presented on Economic Development in the Millennium. AERC-AfDB Project on Africa's Development. African Development Bank, Tunis, November 2006.

- 3 Energy Commission of Nigeria (2002) National Energy Policy. Abuja. August.
- 4 Energy Commission of Nigeria (2005) Renewable Energy Master Plan. Abuja. November.
- 5 Ibitoye, F and A. Adenikinju (2007) Future Demand for Electricity in Nigeria. *Applied Energy* 84, (2007), 492-504.
- 6 Lee, K.S. and A. Anas. "Manufacturers' Responses to Infrastructure Deficiencies in Nigeria: Private Alternatives and Policy Options." Chapter 11 in Chibber, A. and S. Fischer (eds.) *Economic Reform in Sub-Saharan Africa* pp. 106-121.
- 7 World Bank (1994) *Infrastructure for Development*. World Development Report 1994. The World Bank and Oxford University Press.
- 8 World Bank (2000) *Can Africa claim the 21st century*. Washington DC: The World Bank.
- 9 World Bank (2003). *Making services work for the poor people*. World Development Report 2004. Washington DC: The World Bank and Oxford University Press.
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- 10 See Ibitoye and Adenikinju (2005) for some analysis of the future electricity situation in Nigeria.
- 11 This is taken from Ibitoye and Adenikinju (2005)
- 12 See Energy Commission of Nigeria (2005)
- 13 See Energy Commission of Nigeria (2002).

Inaugural Event of the Emirates Association for Energy Economics (EAEE)

Emirates Association for Energy Economics (EAEE) Secretary Tilak Doshi, Executive Director for Energy at the Dubai Multi Commodities Centre, welcomed an audience of around 50 people to the EAEE's inaugural event held at the Madinat Jumeirah in Dubai, taking the opportunity to explain the organisation's goals and the factors behind its establishment.

EAEE President Ali Al Yabhouni then introduced keynote speaker Mr. Guy Caruso, Administrator of the U.S. Energy Information Administration (EIA). Ali, in his capacity as UAE Governor and National Representative for OPEC, also presented a brief overview on the current state of oil markets and prices. Some of Ali's main points were that speculation on futures markets and a lack of investment in refinery capacity and upgrading are major factors in the recent oil price hikes.

Guy Caruso warmly welcomed the idea of setting up a UAE chapter of the IAEE, bringing energy sector professionals together in a region that is playing and will continue to play a major role in this field. In his keynote speech — 'International Energy Outlook to 2030: Implications for the Gulf Region' — Guy presented major findings from the EIA's latest long-term projections for global energy markets through 2030. The key points of Guy's speech were:

- The current increase in energy prices is being driven by supply and demand fundamentals.
- China and India, but also Africa and the Middle East, will be the main sources driving of global energy demand increases.
- The current inadequacy of required investments is a major contributory factor to the tightening energy supply situation.

Guy also took the opportunity to give the audience a brief overview of findings from "Facing the hard truths about energy". This latest report from the U.S. National Petroleum Council (NPC) considers the future of oil and natural gas to 2030 in the context of the global energy system.

Following the keynote speech a wide-ranging question and answer session was held between the speakers and the audience on a variety of issues. Topics discussed ranged from how the US is planning to meet its future growth in LNG demand to the methodologies used by the EIA for making its forecasts.

Current membership of the EAEE stands at 44.



L to R Tilak Doshi, Ali Obaid Al Yabhouni, Ahmed Bin Sulayem, Martin Trachsel and Guy Caruso