Advances in Science and Technology, Vol. 2, No.2, July/August 2008, pp71-77.

A Nuclear Energy Option for Nigeria

Chidi E. Akujor [a,b], Oluwasogo A. Ogungbenro [b*], Gregory A. Alozie [a] and Okey K. Nwofor [c].
[a.] Department of Physics, Federal University of Technology, Owerri, Imo State, Nigeria. [b.] Information and Communication Technology Center, Federal University of Technology, Owerri, Imo State, Nigeria.
[c.] Department of Physics, Imo State University, Owerri, Imo State, Nigeria.
(Submitted: September 20, 2007; Accepted: May 2, 2008)

Abstract

Electric power supply in Nigeria is grossly inadequate, unreliable and has become a major constraint for economic growth and development. The problems include low generation capacity, reliance on ageing hydropower and thermal power stations and the vandalization of gas pipelines to the thermal stations. We propose that nuclear energy has the greatest potential for ameliorating the difficulties and suggest its inclusion in Nigeria's energy matrix in order to increase power supply and enhance efficiency and reliability.

Keywords: Energy, Uranium - Nuclear Power Plant, Electricity production.

1.0 Introduction

The shortage and unreliability of electric power in Nigeria has been a major constraint for growing industrial activity and sophistication in domestic and social activities. The population has also grown from 55 million in 1965 to over 126 million in 2005 leading to increased energy demand without a corresponding increase in electric power supply. The perennial power outages in Nigeria have become a national embarrassment sometimes resulting in social upheavals and fatalities. Existing industrial establishments spend huge resources generating own electric power while new ones must make significant budgetary provision for power generation before take-off. This results in huge production costs and consequent high cost of locally produced goods.

Nigeria's power stations currently have a combined optimum capacity of about 4,000MWe, while actual generation sometimes falls below 2,500MWe and Government estimates of projected capacity is 10,000MWe by the end of 2007. Even if this projection is met, it might still be inadequate, since most of the industries and homes currently running generators will switch to the public-owned power supply system, thus exposing the actual demand situation.

Some of the reasons for the prevailing inadequacy in electric power supply are:

i. General low-level capacity of all the power stations.
ii. Reliance on ageing hydropower stations and occasional drop in water levels in the associated rivers.
iii. Unreliability of gas supplies to the gas thermal stations, sometimes resulting from gas pipeline vandalization and corrosion attacks.
iv. A thriving business of importation of cheap and fragile power generating sets which is unhealthy for the nation.

In this paper, we discuss the current electric power situation in Nigeria. We attempt to show that of the neglected energy sources, nuclear energy offers the greatest potential for ameliorating the current difficulties in the nation's power sector and consequently make suggestion for its inclusion in the nation's power matrix.

2.0 The State of Current Generation

The Federal Government has commenced the restructuring of the nation's power company. Its name has been changed from National Electric Power Authority (NEPA) to Power Holding Company of Nigeria (PHCN). The thrust of the changes would be splitting of this huge establishment into smaller companies including an independent power distribution company. It has also launched a

* Corresponding author e-mail: sogo@futongr.com

"National Integrated Power Project" as an intervention step to improve power supply through short-term implementation of Generation, Transmission, Distribution and Gas Supply projects (see Federal Ministry of Power and Steel, 2006).

The existing public-owned power stations have optimum capacity to generate 4,6363MWe from a combination of hydropower and thermal power stations (see Table 1), while additional 860MWe are obtained from the recently commissioned Independent Power Stations (IPPs). There are four additional public-owned thermal power stations under construction at Geregu, Kogi State (414MWe), Omotosho, Ondo State (335MWe), Papalanto, Ogun State (335MWe) and Alaoji, Abia State (504MWe) with a total capacity of 1,588MWe. The ongoing Independent Power Projects (IPPs[1]) at Omoku, Rivers State (150MWe), Obajana (350MWe) and Ibom, Akwa Ibom (188MWe) would yield a combined output of 688MWe. In addition, there are seven new power projects being executed by the Federal Government under the National Integrated Power Project at different locations in the Niger Delta with a combined capacity of 2,556MWe, in order to harness the existing and abundant gas resources in the region (see Table 2). Thus, the combined capacity of all the power stations is expected to be 10,328MWe achievable at close of construction in December 2007.

The focus of the new power projects is the utilization of the abundant petroleum and gas resources available locally. The other energy sources like Coal, Solar energy, Wind energy, Biomass and Biogas and Nuclear energy, which are also abundant or have good prospects in Nigeria, have surprisingly been neglected.

It is on the basis of the urgent need to improve Nigeria's energy generation capacity that several calls have been made for diversification of the country's energy generation sources. Nwofor et al. (2007) have discussed in particular a method for making energy diversification choices in Nigeria, which relies heavily on consideration of availability, economy and environmental sustainability of energy options. These considerations have also been brought to bear in our current advocacy of the use of Nuclear energy for electricity generation in Nigeria.

Table 1: Power Stations in Nigeria

Power Stations	Type	Capacity (MWe)
Kainji	Hrdropower	640
Jebba	Hydropower	560
Shiroro	Thermal power	600
Egbin	Thermal power	1200
Afam	Thermal power	456
Sapele	Thermal power	240
Delta	Thermal power	900
Ijora	Thermal power	40
AES (IPP)	Thermal power	300
Agip (IPP)	Thermal power	480
Ajaokuta Steel Coy Ltd (IPP)	Thermal power	80
Total		5,496

Source: Federal Ministry of Power and Steel 2006.

3.0 Why the Nuclear Energy Option?

The world's Uranium reserves are mostly located in Australia (35%), countries of the former USSR (29%), Canada (13%), Africa (8%) and South America (8%). In terms of production, Canada (33%) is followed by Australia (15%) and Nigeria (10%). Other producers are Kazakhstan, Namibia, Russia, South Africa, the United States of America and Uzbekistan (Fells and Hore-Lacy, 2000). Of all these (except Namibia), Nigeria is the only country that is not utilizing her nuclear (fission) energy resources for electric power generation.

Onyejekwe (1981) and Akujor (1985) had mentioned the potential of Nigeria to achieve nuclear energy production for electricity. First, the raw materials are available. Uranium and Thorium occur in pyrochlore in the Nigerian states of Gombe, Plateau, Sokoto and Cross River. The chemical

Table 2: Power plants under construction in Nigeria

Power Stations	Type	Capacity MWe
Geregu	Thermal power	414
Omotosho	Thermal power	335
Papalanto	Thermal power	335
Alaoji	Thermal power	504
Calabar	Thermal power	561
Egbema	Thermal power	338
Eyaen	Thermal power	451
Gbarain / Ube	Thermal power	225
Ikot Abasi	Thermal power	300
Sapele	Thermal power	451
Omoku	Thermal power	230
Omoke[1]	Thermal power	150
Obajana[1]	Thermal power	350
Ibom[1]	Thermal power	188
Total		4,832

Source: Federal Ministry of Power and Steel 2006.
[1] Independent Power Projects

analysis shows contents of thorium oxide (3.3%), uranium oxide (3.3%) and 41.1% of oxides of tantalium and niobium. The Nigerian Uranium Mining Company, which is based in Gombe, has also interest in the exploitation of large uranium deposits in Niger Republic. Moreover, Nigeria has the abundance of quality manpower to implement and maintain a nuclear power programme. Nigeria's geopolitical strategic position and responsibility in the West-African Sub-region and Africa confers a responsibility for spearheading research and development in a vital area as Nuclear energy programme.

Nuclear power generation is the most prominent but also the most contested nuclear activity (William 2003 [6]; Dowdeswell 2004; ElBaradei 2004; Caldicott 2005); interest in nuclear energy is rightly or wrongly shaped by perceptions and misperceptions about the attendant risk. About 16% of the world's total electricity production comes from 441 nuclear power plants operational in 31 countries (Burkart and Rosenthal 2003). The nuclear share of electricity produced is put at 20%, 34%, 77% and 58% for the developed countries of the United States of America, Japan, France and Belgium respectively. In Table 3, we present the nuclear share of electricity produced by some developing countries with similar geopolitical status as Nigeria. We note that all the major developing countries with the same geopolitical status as Nigeria are building Nuclear reactors for electric power generation. As of May 2006, twenty-seven units of Nuclear Power Plants (NPPs) of 21,051MWe capacity are under construction in twelve countries – mainly third world countries, while in some other eleven countries thirty-eight units with total capacity of 40,737MWe have gotten approval for construction and one hundred and fifteen other units of 83,620MWe capacity are been proposed by nineteen countries – mainly the third world countries. For example, South Africa with a population of about 44 million has a total energy generation capacity of about 28,000MWe of which 6.5% is derived for nuclear power plants. She also has plan to boost her electric power generation capacity by another 4,165 through nuclear energy. From Table 3, Nigeria's energy per capita (EPC) is 36.6 Watts which is only ~ 13.9% of the EPC for Egypt and ~ 3.6% that of South Africa. Though Nigeria's population is about three rimes that of South Africa, her projected electricity generation capacity by 2007 is only about one-third of South Africa's current generation capacity.

In 2003, the nation witnessed a 2.6% increase (to 11,528,790.88 million tones) in her aggregate consumption of petroleum products, which necessitated massive importation of petroleum products by the Nigerian National Petroleum Corporation (NNPC) and major oil marketers to meet domestic shortages (CBN Annual report 2003 [11]). The inclusion of the nuclear energy option in the nation's power generation will ensure the availability of more fossil fuels – gas and oil – both for exportation and local consumption. Though the cost of building a nuclear power station is more than that for the thermal or hydropower station, the nuclear fuel (including its enrichment if needed) costs much less than oil, gas or coal. Thus the overall expected cost for energy conversion to electricity could come out much the same or even cheaper for nuclear compared to thermal plants. The construction of nuclear plants and their components will stimulate the local industries and reduce long-term commitments to buying fuels from abroad.

Also, the nuclear fuel is a highly concentrated source of energy, making its transportation much easier and cheaper. Nuclear Power Plants are also more efficient. About 40 million kilowatt-hour (KWh) of electricity can be generated from one tonne of natural Uranium, while over 16,000 tonnes or 80,000 barrels of coal or oil respectively is required to generate the same amount of energy. Thus the nuclear fuel cost contribution to the overall cost of the electricity production is relatively small. This implies that even a large (nuclear) fuel price escalation will have relatively little effect on the total cost of power generation (Stoke, Seager and Capener 1975; Gross 1979).

The volume of greenhouse gases emitted into the atmosphere due to fossil fuel consumption is increasing with grave ecological consequences. In trying to increase our energy production, we must at the same time try to reduce our emission of greenhouse gases to ensure environmental sustainability. Thus, there is the need to diversify our energy mix to reduce the share supplied by fossil fuels. Operating a nuclear power plant is environment friendly; nuclear fuel is a fairly clean source of energy and thus approximately pollution free unlike the fossil fuels (Mourogov 2003; Kristof 2005). Although Caldicott (2005) had disagreed that nuclear power is a clean source of energy, he nevertheless concedes that it produces only about one-third of the greenhouse gases produced by modern natural-gas power stations.

The subject of radiation and radioactivity is an area where detailed studies have been carried out. Radioactivity level is well measured and thus the radiation hazards and effects associated with operating a nuclear power plant are well understood unlike the delayed hazardous effects associated with the fossil fuels. Modern nuclear power plants are designed to substantially contain all hazardous scenario associated with radiation and radioactivity (Onyejekwe 1977; Ingersoll *et al*. 2005). In comparison with other major air-pollution episodes in the world, nuclear accidents have been far less frequent (see Khaiwal 2004). The only case in which the nuclear power plant failed in containing radiation is the Chernobyl 1986 in Ukraine in which more than 31 lives were lost. This needs to be compared to the 1979 Machhu II hydroelectric dam failure in India in which 2,500 people died, or to Warri (Nigeria) 1998 oil pipeline leakage that resulted in a fire out-break that took more than 500 lives (Hore-Lacy 2003; Barre 2003).

Furthermore, efforts in managing nuclear wastes have been characterized by positive trends. Wastes generated in nuclear plants are grouped under the high-level wastes and the low- and intermediate level wastes. These wastes can be recycled for further use. The consensus is that long-term safety is found through deep geological disposal (Thegerstrom 2004; Kincaid *et al*. 2004). Though Nigeria does not operate a nuclear plant, she already generates nuclear wastes (especially in the application of nuclear techniques in the oil sector). Thus, an option in nuclear energy will also help in appropriately managing all associated wastes with nuclear techniques.

Other beneficial scientific and technological spin-offs from enhanced nuclear energy activity include the use of nuclear science and applications:

i. In food processing: the use of irradiation to effectively inactivate various food-borne pathogenic bacteria and parasites dates back to the 1970s. For example, a total of 243,000 metric tonnes of food were processed by irradiation worldwide in 1999 (Loaharanu 2001).

ii. In agriculture: major nuclear application in enhancing the genetic quality, improving quantity and reducing germination period of agricultural produce are mutation breeding and pest control (Micke 1999; Liu *et al*. 2004).

iii. In industry: a broad and diverse array of nuclear applications are routinely employed in physical measuring gauges, humidity or density meters, oil well logging tools and smoke detectors. In the petroleum industry, nuclear techniques are

Table 3: NPPs share of electricity production in some developing countries like Nigeria.

Country	NPP Units	NPP Capacity (MWe)	Total Power Generation (MWe)	% of NPP	Population (in millions)	Energy per capita x 10^{-6} (MWe)
Argentina	2	935	8,202	11.4	36.96	221.9
	1[a]	692				
Brazil	2	1,901	63,875,	3	174.47	366.1
	1[b]	1,245				
Egypt	-	-	20,000	-	76.12	262.7
	1[c]	600				
India	15	2,993	74,993	4	1,029.99	72.8
	8[a]	3,638				
	24[c]	13,160				
Indonesia	-	-	-	-	203.99	-
	4[c]	4,000				
Iran	-	-	37,460	-	67.48	555.1
	1[a]	915				
	2[b]	1,900				
	3[c]	2,850				
Korea RO (South)	20	16,840	35,721	47	47.90	745.7
	8[b]	9,200				
Mexico	2	1,320	20,125	6.5	101.88	197.5
	2[c]	2,000				
Nigeria	-	-	4,636	-	126.64	36.6
Pakistan	2	425	21,133	2	144.62	146.1
	1[a]	300				
	2[c]	1,200				
South Africa	2	1,842	28,338	6.5	43.59	650.1
	1[b]	165				
	24[c]	4,000				
Vietnam	-	-	14,320	-	79	181.3
	2[c]	2,000				

NPP is the nuclear power plants operational in the country. % of NPP is the share of the total electricity generation by the nuclear plants. [a.] These NPP units are under construction. [b.] These are NPP units in plan i.e. approval and funding are in place, or construction well advanced but suspended indefinitely. [c.] These are proposed NPP units, but without funding or approvals.

used for refining and for enhancing the extraction of oil from the ground and tar sands. A major future use of nuclear techniques is likely to be for hydrogen production, initially by electrolysis but ultimately by thermo-chemical means (Forsberg 2002; Lahoda and Mazzoccoli 2003; Forsberg 2004).

iv. In healthcare: nuclear techniques have contributed significantly to prevention, diagnosis and cure of different ailments (Levin *et al.* 2001; Groth *et al.* 2001; Samiei, Rosenthal and Kinley III 2005). Future application of the nuclear technique is in desalination – the production of portable water from seawater, (Konishi and Misra 2001; Aggarwal and Boussaha 2005).

4.0 Conclusion

Electric power supply in Nigeria is currently inadequate and very erratic. The current installed optimum capacity is 4,636MWe but actual production could be as low as 2,500MWe. The total projected output of 10,328MWe by the year 2007 would be inadequate to redress the current situation in the nation's power sector since there have been a significant imbalance between the rates at which electric power demand is increasing and that at which it is being generated. There is, therefore, the urgent need to diversify the nation's electric power generation to include more reliable and efficient energy sources. The greatest potential is offered by the nuclear (fission) energy. The nuclear fuel – uranium being a cheap, concentrated energy source is widely distributed across the nation's landscape; it also remains a most reliable fuel for reducing global warming and environmental pollution.

The dangers inherent in operating nuclear power plants have been subject of detailed investigation and their associated side effects are well understood. To safely operate a nuclear power plant only requires well skilled and properly motivated personnel, which the country can afford. The nuclear wastes generated by NPPs are well planed for in their construction scheme, and are often recycled for use in other sectors of the economy. This is quite unlike wastes generated, and dangers inherent in running other types of power stations.

Though the nuclear energy option may not hold the absolute solution to the nation's energy crises, there is too little a possibility of a solution without it.

References

Aggarwal, P. and Boussaha, A. 2005, "H_2O know- how", Bull. International Atomic Energy Agency, **47,** 38.

Akujor, C.E. 1985, "Nigeria's energy sources", Energy – International J., **10,** 1075.

Barre, B.2003, "Making nuclear power sustainable", Bull. International Atomic Energy Agency, **45,** 54.

Burkart, W. and Rosenthal, M.D. 2003, "Seeing the impact", Bull. International Atomic Energy Agency, **45,** 48.

Caddicott, H. 2005, "Nuclear reactions", Bull. International Atomic Energy Agency, **47,** 55.

CBN Annual Report and Statement of Accounts, 2003, pp71 and 148.

Dowdeswell, E. 2004, "The continuing quest", Bull. International Atomic Energy Agency, **46,** 33.

Elbaradei, M. 2004, "Nuclear power", Bull. International Atomic Energy Agency, **46,** 57.

Federal Ministry of Power and Steel 2006, National Integrated Power Project goundbreaking ceremony for the 338MW gas turbine power station, Ohaji/Egbema.

Fells, N.S. and Hore-Lacy, I. 2000, "Vision of a nuclear future", paper presented at the Basin Nuclear Energy Society conference on: Nuclear 2000.

Forsberg, C.W. 2004, "A large low-pressure advanced high temperature reactor (AHTR)", paper presented at the 14th Pacific Basin Nuclear conference: New technology for a new era, Honolulu, Hawai.

Forsberg, C.W. 2002, "The advanced high-temperature reactor for hydrogen production", paper presented at a technical workshop on: Large scale production of hydrogen from nuclear power – fission and fusion, California.

Groth, S., Khan, B., Robinson, A. and Hendrichs, J. 2001. "Nuclear science fights malaria", Bull. International Atomic Energy Agency, **43,** 33.

Gross, R.A. 1979, "The potential of nuclear energy", in Energy for survival, H. Mesel (ed), Perganon press, pp 211.

Hore-Lacy, I. 2003, Nuclear Electricity, 7th edition

(Uranium information center LTD and World Nuclear Association).

Ingersoll, D.T., Parma, E.J., Forsberg, C.W. and Reneier, J.P. 2005, "Core physics characteristics and issues for the advanced high-temperature reactor (AHTR) concept", paper presented at the science meeting on: Advanced reactors with innovative fuels (and coolants), Oak Ridge National Laboratory.

Khaiwal, R. 2004, "Air pollution episodes; what to learn and what to forget", lecture presented at European Research Course on Atmosphere(ERCA), Grenolde France, Feb. 2004.

Kincaid, C.T., Bryce, R.W. and Bulk, J.W. 2004, "Technical scope and approach For the 2004 composite analysis of low-level waste disposal at the Hanford site", United States Department of Energy.

Konishi, T. and Misra, B.M. 2001, "Fresh water from the seas", Bull. International Atomic Energy Agency, **43,** 5.

Kristof, N.D. 2005, "Nuclear reactions", Bull. International Atomic Energy Agency, **47,** 55.

Lahoda, E.J. and Mazzoccoli, J.P. 2003, "The Westinghouse sulphur process for hydrogen production", paper presented at the symposium on: Nuclear energy and the hydrogen economy, Massachussett Institute of Technology.

Levin, V., Meghzifene, A., Izewska, J. and Tatsuzaki, H. 2001, "Improving cancer care", Bull. International Atomic Energy Agency, **43,** 25.

Liu, L., Zanten, L.V., Shu, Q.Y. and Maluszyuski, M. 2004, "Officially released mutant varieties in China", Review - International Atomic Energy Agency, No 14, pp1-64.

Loaharanu, P. 2001, "Rising calls for food security", Bull. International Atomic Energy Agency, **43,** 37.

Micke, A. 1999, "Mutations in plant breeding", in Breeding in crop plants: Mutations and In Vitro mutation breeding, ed. Saddiue, B.A. and Khan, S., Kalyain publishers, Ludhiana (India), pp1-19.

Mourogov, V. 2003, "The promise of innovation", Bull. International Atomic Energy Agency, **45,** 59.

Nwofor, O.K., Chineke,T.C., Akujor, C.E. and Okoro, U.O. 2007, "Energy diversification choices for Nigeria; optimization by the criteria ranking method", Energy and Environment, **18** (5), 577.

Onyejekwe, D.C. 1981, "Prospects for the development of nuclear technology in Nigeria", Energy – The international J., **6,** 1053.

Onyejekwe, D.C. 1977, "Optimization of biological shields in nuclear reactors", paper presented at the Science Association of Nigeria conference, Ibadan.

Samiei, M., Rosenthal, M.D. and Kinley III, D. 2005, "No time to lose", Bull. International Atomic Energy Agency, **47,** 27.

Stoker, H.S., Seager, S.L. and Capener, R.L. 1975, "Energy – from source to use, Scott, Foreman and Company, pp190.

Thegerstrom, C. 2004, "Down to earth and below", Bull. International Atomic Energy Agency, **46,** 36.

Williams, L. 2003, "Setting the standard", Bull. International Atomic Energy Agency, **45,** 57.